Nos. 79-1429 and 79-1583

IN THE

Supreme Court of the United States

OCTOBER TERM, 1980

AMERICAN TEXTILE MANUFACTURERS INSTITUTE, INC., ET AL., *Petitioners,*

v.

RAY MARSHALL, SECRETARY OF LABOR, UNITED STATES DEPARTMENT OF LABOR, ET AL., *Respondents.*

NATIONAL COTTON COUNCIL OF AMERICA, *Petitioner,*

v.

RAY MARSHALL, SECRETARY OF LABOR, UNITED STATES DEPARTMENT OF LABOR, *Respondent.*

On Writs of Certiorari to the United States Court of Appeals for the District of Columbia Circuit

JOINT APPENDIX

NEIL J. KING
Counsel of Record
A. STEPHEN HUT, JR.
ANDREW N. VOLLMER
WILMER & PICKERING
1666 K Street, N.W.
Washington, D.C. 20006
(202) 872-6000

WADE H. MCCREE, JR.
Solicitor General
KENNETH S. GELLER
Deputy Solicitor General
BARRY SULLIVAN
Assistant to the Solicitor General
Department of Justice
Washington, D.C. 20530
(202) 633-2217

(Additional Counsel listed inside)

PETITIONS FOR WRIT OF CERTIORARI FILED MARCH 14, 1980 (No. 79-1429) AND APRIL 9, 1980 (No. 79-1583)
CERTIORARI GRANTED ON OCTOBER 6, 1980

ROBERT H. BORK
142 Huntington Street
New Haven, Connecticut 06511

GREGORY B. TOBIN
OGLETREE, DEAKINS, NASH, SMOAK, STEWART AND EDWARDS
First National Bank Tower
Two Peachtree Street, N.W.
Atlanta, Georgia 30383

Counsel for Petitioner American Textile Manufacturers Institute, Inc.

ROBERT T. THOMPSON
GARY S. KLEIN
THOMPSON, MANN & HUTSON
The Daniel Building
Suite 2222
Greenville, S.C. 29602

Counsel for Petitioner Milliken and Company

JOSEPH K. MADDOX, JR.
P. O. Box 5784
Spartanburg, S.C. 29304

Counsel for Petitioner Spartan Mills

ROBERT T. THOMPSON
GARY S. KLEIN
THOMPSON, MANN & HUTSON
The Daniel Building
Suite 2222
Greenville, S.C. 29602

Counsel for Petitioner Hermitage, Inc.

SAMUEL K. ABRAMS
BRIAN E. MORAN
BAKER & HOSTETLER
818 Connecticut Ave., N.W.
Washington, D.C. 20006

H. J. ELAM, III
NEIL W. KOONCE
Cone Mills Corporation
Greensboro, N.C. 27405

Counsel for Petitioner Cone Mills Corporation

CARIN A. CLAUSS
Solicitor of Labor
BENJAMIN W. MINTZ
Associate Solicitor
ALLEN H. FELDMAN
DENNIS K. KADE
DIANE E. BURKLEY
JOHN A. BRYSON
Attorneys
Department of Labor
Washington, D.C. 20210

Counsel for Respondent Secretary of Labor

GEORGE H. COHEN
Counsel of Record for Union Respondents
ROBERT M. WEINBERG
JEREMIAH A. COLLINS
BREDHOFF, GOTTESMAN, COHEN, CHANIN, WEINBERG & PETRAMALO
1000 Connecticut Ave., N.W.
Washington, D.C. 20036
(202) 833-9340

Counsel for American Federation of Labor and Congress of Industrial Organizations, Industrial Union Department, AFL-CIO and Amalgamated Clothing & Textile Workers Union, AFL-CIO

LAURENCE GOLD
815 16th Street, N.W.
Washington, D.C. 20006

J. ALBERT WOLL
General Counsel, AFL-CIO
815 15th Street, N.W.
Washington, D.C. 20005

ELLIOT BREDHOFF
General Counsel
Industrial Union Department, AFL-CIO
1000 Connecticut Ave., N.W.
Washington, D.C. 20036

ARTHUR M. GOLDBERG
General Counsel
Amalgamated Clothing & Textile Workers Union
15 Union Square
New York, New York 10003

Of Counsel

DAN M. BYRD, JR.
J. SPRATT WHITE
P. O. Box 70
Fort Mill, S.C. 29715

Counsel for Petitioner
Springs Mills, Inc.

ROBERT H. BORK
142 Huntington Street
New Haven, Connecticut 06511

Counsel for Petitioner
Fieldcrest Mills, Inc.

THOMAS A. EVINS
CLYDE H. HAMILTON
BUTLER, MEANS, EVANS & BROWNE
P. O. Box 451
Spartanburg, S.C. 29304

Counsel for Petitioner
Arkwright Mills

ROBERT T. THOMPSON
GARY S. KLEIN
THOMPSON, MANN & HUTSON
The Daniel Building
Suite 2222
Greenville, S.C. 29602

Counsel for Petitioner
Blair Mills, Inc.

HARLAN H. HUNTLEY
ROGER L. TUTTLE
2291 Memorial Drive
Danville, Virginia 24541

Counsel for Petitioner
Dan River, Inc.

THOMAS A. EVINS
CLYDE H. HAMILTON
BUTLER, MEANS, EVINS & BROWNE
P. O. Box 451
Spartanburg, S.C. 29304

Counsel for Petitioner
Mayfair Mills

FRED M. RICHARDSON
LOVIC A. BROOKS, JR.
CHARLES A. EDWARDS
CONSTANGY, BROOKS & SMITH
1900 Peachtree Center Building
230 Peachtree Street, N.W.
Atlanta, Georgia 30303

Counsel for Petitioner
Riegel Textile Corporation

RICHARD H. MONK, JR.
C. POWERS DORSETT
West Point-Pepperell, Inc.
P. O. Box 71
West Point, Georgia 31833

Counsel for Petitioner
West Point-Pepperell, Inc.

CHARLES M. CRUMP
Counsel of Record
APPERSON, CRUMP, DUZANE & MAXWELL
2610 100 North Main Building
Memphis, Tennessee 38103
(901) 525-1711

JOSEPH A. MOSS
4143 27th Street, N.
Arlington, Virginia 22207
(703) 525-4063

Counsel for Petitioner
National Cotton Council
of America

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I. Relevant Docket Entries

in

American Federation of Labor & Congress of Industrial Organizations, *et al.*,

v.

Ray Marshall, *et al.*

No. 78-1562 (D.C. Cir.)

(and Consolidated Case Nos. 78-1736, 78-1979, 78-1980, 78-1981, 78-1982, 78-1983, 78-1984, 78-1986, 78-1987, 78-1988, 78-1989, 78-1990, 78-1991, 78-1992, 78-1993, 78-2013, 78-2014, 78-2016 and 78-2018)

Date	Filings, Orders, and Proceedings
1978	
June 19	Filing of Petition for Review of Cotton Dust Standard by American Federation of Labor & Council of Industrial Organizations, *et al.* (D.C. Cir.)
June 19	Filing of Petition for Review of Cotton Dust Standard by American Textile Manufacturers Institute, Inc. (4th Cir.)
July 27	Filing of Petition for Review of Cotton Dust Standard by Milliken and Company (4th Cir.)
August 2	Filing of Petition for Review of Cotton Dust Standard by Arkwright Mills (4th Cir.)
August 3	Filing of Petition for Review of Cotton Dust Standard by Spartan Mills (4th Cir.)
August 7	Filing of Petition for Review of Cotton Dust Standard by Blair Mills (4th Cir.)
August 7	Filing of Petition for Review of Cotton Dust Standard by Hermitage, Inc. (4th Cir.)
August 10	Filing of Petition for Review of Cotton Dust Standard by West Point-Pepperell, Inc. (5th Cir.)
August 14	Filing of Petition for Review of Cotton Dust Standard by Dan River, Inc. (4th Cir.)
August 15	Filing of Petition for Review of Cotton Dust Standard by Cone Mills Corporation (4th Cir.)
August 16	Filing of Petition for Review of Cotton Dust Standard by National Cotton Council of America (6th Cir.)

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Date	Filings, Orders, and Proceedings
1978	
August 16	Filing of Petition for Review of Cotton Dust Standard by Springs Mills (4th Cir.)
August 16	Filing of Petition for Review of Cotton Dust Standard by Mayfair Mills (4th Cir.)
August 17	Filing of Petition for Review of Cotton Dust Standard by Riegel Textile Corporation (4th Cir.)
August 18	Filing of Petition for Review of Cotton Dust Standard by Fieldcrest Mills, Inc. (4th Cir.)
October 3	Order transferring Cotton Dust Petitions for Review pending in the Fourth Circuit to the District of Columbia Circuit
October 6	Order transferring National Cotton Council of America Petition for Review from the Sixth Circuit to the District of Columbia Circuit
October 7	Order transferring West Point-Pepperell, Inc. Petition for Review from the Fifth Circuit to the District of Columbia Circuit
October 13	Order consolidating Cotton Dust cases in the District of Columbia Circuit
December 15	Filing of Opening Brief of Petitioners American Federation of Labor & Congress of Industrial Organizations, *et al.*
December 15	Filing of Joint Brief of the American Textile Manufacturers Institute, Inc., *et al.*
December 15	Filing of Supplemental Brief of Petitioner, National Cotton Council of America
December 15	Filing of Amicus Curiae Brief of American Farm Bureau Federation

Date	Filings, Orders, and Proceedings
1979	
January 26	Filing of Brief for the Secretary of Labor
February 7	Filing of Reply Brief of Petitioner National Cotton Council of America
February 7	Filing of Reply Brief and Brief in Intervention of Petitioners American Federation of Labor & Congress of Industrial Organizations, *et al.*
February 7	Filing of Joint Reply Brief of the American Textile Manufacturers Institute, Inc., *et al.*
February 14	Oral Argument in the United States Court of Appeals for the District of Columbia Circuit
October 24	Entry of Judgment and Opinion of the United States Court of Appeals for the District of Columbia Circuit (Reprinted in the Appendix to the Petition for Writ of Certiorari at 19)
November 7	Filing of Petition for Rehearing and Suggestion for Rehearing En Banc of Petitioner, National Cotton Council of America
November 7	Filing of Joint Petition for Rehearing and Suggestion for Rehearing En Banc of American Textile Manufacturers Institute, Inc., *et al.*
1980	
January 11	Order denying Petitions for Rehearing (Reprinted in the Appendix to the Petition for Writ for Certiorari at 103)
January 11	Order denying Suggestions for Rehearing *En Banc* (Reprinted in the Appendix to the Petition for Writ of Certiorari at 104)
January 16	Motion of National Cotton Council of America for Stay of Mandate

Date	Filings, Orders, and Proceedings
1980	
January 16	Filing of Joint Motion for Stay of Mandate by the American Textile Manufacturers Institute, Inc., *et al.*
January 17	Filing of Opposition to Motions for Stay of Mandate by the Secretary of Labor
January 17	Filing of Response of Union Petitioners to Motions for Stay of Mandate
January 22	Order directing clerk to issue mandate (Reprinted in the Appendix to the Petition for Writ of Certiorari at 106)
March 14	Filing of Petition for a Writ of Certiorari by Petitioners American Textile Manufacturers Institute, Inc., *et al.*
April 9	Filing of Petition for a Writ of Certiorari by Petitioner National Cotton Council of America
October 6	Entry of Order granting Petitions for Writs of Certiorari (Reprinted in this Joint Appendix at 489)

II. EXHIBITS SUBMITTED IN THE PROCEEDINGS BEFORE THE AGENCY

EXHIBIT 1

National Institute for Occupational Safety and Health, "Criteria for a Recommended Standard: Occupational Exposure to Cotton Dust"

* * * * *

Feasibility of Control

Control of dust levels in cotton-processing operations can be achieved by changing or treating the raw material which is the source of the dust, by changing the process which produces the dust, or by removing the dust from the air once it is generated.

The transition from natural to synthetic fibers in the past decade has resulted in lower byssinosis-producing dust levels in those mills using synthetics or blends. Merchant et al [18] reported a median dust level of 0.485 mg/cu m for 493 samples collected in mills working with pure cotton and a median dust level of 0.163 mg/cu m for 237 samples collected from mills using blends of natural and synthetic fibers. The synthetic fibers are virtually trash free and thus contribute little to the total sample collected. [136] It would be expected that, as the synthetic content of the raw material increased, the dust levels in most work areas would decrease.

A second method of changing the raw material is through the improvement of growing techniques to reduce the trash content of the cotton. Approaches such as developing cotton varieties which shed their bracts prior to maturation and harvest or the development of dwarf determinant cottons with increased fruiting potential compared to the production of vegetative parts [137] offer future potential methods of dust control, but at present these approaches are not feasible. There is little doubt that exposure to cotton dust trash has been greatly augmented by the replacement of handpicking by machines. [138] Studies are in progress to find new chem-

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icals which will more efficiently defoliate cotton and reduce the trash content of the harvested seed cotton. [137]

A third method of changing the raw material is by steaming. Studies of this technique indicated that steaming could reduce the toxic effect of the cotton dust without rendering the cotton unsuitable for processing. [94] Some investigators conclude that the byssinosis-producing dusts are not removed or detoxified, but are just made to adhere more firmly to the cotton fibers; therefore the byssinosis problem is not solved but only moved from the opening, picking, and carding areas to the winding and weaving operations. [139] However, recent studies in a cotton spinning plant do not show an increase in downstream dust levels when processing steamed cotton. [140] Thus, while steaming may not be at this time a feasible alternative to dust control, it may become effective as a supplementary control method after further development. [140] Work is also in progress on improved ginning methods to allow for more efficient trash separation and/or fractionation. [137]

There appears to be little that can be done now to change the process in which cotton fibers are formed into yarn and woven into cloth in order to control dust production. The cotton manufacturing process is essentially one of fiber cleaning and alignment with the desired goal of removing all material in the cotton except the mature fibers. The dust in the cotton is thus an unwanted byproduct which must be dealt with. It is possible that the ginning process could be changed, and work is being actively pursued along these lines [137]; but at present process change does not appear to be a feasible alternative to dust control.

There are also a number of environmental factors which can be adjusted to some extent to control dust levels. As the opening and cotton cleaning machinery more efficiently removes trash and dust from the cotton

stock, the release of this material into the work areas diminishes. Thus, dust levels in the picking room, cardroom, and subsequent operations can be reduced by better cleaning of the cotton in the opening and cleaning line. [141]

Decreasing the production machine density in a work area should decrease the dust levels in that area also. Conversely, if the machines are crowded together, higher dust levels would be expected. Dust emission is also increased by higher card speeds. Improperly or poorly maintained production machinery can also lead to higher dust levels. Hocutt [141] reports that cardroom dust levels are lower when the cards are well maintained and properly operated with alert operating personnel using precise machine settings.

Large central air-conditioning systems will tend to even out dust concentrations over the entire mill. [141] Of course, this might create new problems instead of getting rid of one, since it would cause increased dust level in some area while decreasing those in others. However, air-conditioning a textile mill does provide some dust control, but the control is incidental and the increased dust load in the air-conditioning unit will result in increased maintenance costs and impede the performance of the air conditioner. Dust is removed by the washer, a unit which acts as the primary humidifier and heat exchanger in the air-conditioning system. The washer is about 25% efficient for large particles [141] and much less efficient for smaller ones. Reliance on the air conditioner for dust control means that the dust must travel through the work area to reach the air-conditioner inlet, usually located on one wall of the room. Thus, the very nature of the system makes it inefficient for dust reduction or removal.

The capture and removal of dust from the air after it has been generated from the cotton represents the most

widespread and efficient method of dust control at the present time. Table IV-3 gives summarized results from a study conducted recently by Barr et al [127] on the effectiveness of dust controls in mills having different degrees of dust control and processing varying grades of cotton. These results serve only to indicate the ranges of concentrations which may be expected for the different operations, with and without dust controls.

It appears that in some instances there may be dust concentrations (<0.5 mg/cu m) near cotton processing operations without dust control devices, but this would be the exception rather than the rule.

TABLE IV-3

RANGE OF TYPICAL LINT AND DUST CONCENTRATIONS

Operation	Total (mg/cu m)	Dust excluding lint (mg/cu m)*
Picking, no control	—	0.6-1.6
Picking, control	0.4-0.7	0.3-0.4
Opening and picking, no control	1.5-9.1	0.2-1.9
Opening and picking, control	—	0.3-0.5
Carding, no control	5.2-21.2	0.3-5.4
Carding, control	0.5-8.4	0.1-4.2

* As measured by the vertical elutriator from reference 127.

In a study of four cards, Wood and Roach [11] found dust removal to be less effective than indicated in Table IV-3; total dust levels ranged from 4.2-5.8 mg/cu m without dust extraction to 1.3-4.3 mg/cu m with dust extraction.

Efficient dust removal in cotton processing areas depends on two factors. First, there must be effective dust-capturing devices located at the points where dust could be generated. The captured dust is then transported away from the point of generation to a point where it

can either be discharged to the outside atmosphere or removed by some means from the carrier air stream. Direct discharge of the captured dust to the ouside atmosphere is not practical for two reasons. The dust is emitted in sufficient quantity to quickly produce its own air pollution problem outside, and some will probably find its way back into the work area negating the effect of the dust capture mechanisms. A second and often more compelling reason for not directly discharging into the atmosphere is the loss of conditioned air which must be replaced by new, heated or cooled makeup air. The quantities of air required for effective dust capture are large enough so that the usual practice is to recycle this air volume within the mill. [127]

Air which receives dust at one point and is cleaned at another point during complete recirculation will with time reach an equilibrium dust concentration. With ideal mixing, this concentration will equal the cleaned air dust concentration plus the ratio of the dust production rate divided by the recirculated air flow rate. [127] With good dust capture (low dust production rate) or a large recirculating air flow rate the concentration of dust in the air which is returned to the workroom will eventually determine the concentration of dust in that space. The isolation of dusty operations, successful in controlling dust exposures in other industries, has not been widely adopted in cotton mills.

* * * * *

EXHIBIT 6-1

Roach & Schilling, "A Clinical and Environmental Study of Byssinosis in the Lancashire Cotton Industry."

Our suggested grading of workrooms according to dustiness was arrived at after consideration of the prevalence in groups exposed to similar concentrations for similar lengths of time. We might have deduced permissible levels of dustiness from dose response curves in a similar way to that suggested by Roach (1953). However, we were hesitant to do this because of the possible effects of selection in those groups with the highest prevalence of byssinosis. People with byssinosis are generally aware that the dust affects their breathing and it is likely that they will leave their jobs more readily than those who are not so affected. To this extent the people working in a cotton mill are likely to be a selected population, particularly those groups who work in the dustiest jobs and are in consequence affected most by dust. To deduce permissible levels of dustiness from dose-response relationships we would have had to assume that selection operates in an exactly similar way in all mills or does not operate at all.

* * * * *

EXHIBIT 6-16

BYSSINOSIS IN THE UNITED STATES

Dr. Arend Bouhuys
J.B. Pierce Foundation Laboratory
Yale University School of Medicine
New Haven, Conn.

I would like to discuss some of the main points concerning the definition of byssinosis. At risk are cotton, flax, and hemp workers in carding and other types of dusty work. The symptoms of the disease are chest tightness, cough, and wheezing. The peculiar property of these symptoms is the timing of their occurrence. In the first few years of exposure, symptoms occur on Monday, or other days after absence from the work environment; later, symptoms occur on other days of the week; and eventually, symptoms are continuous, even in the absence of dust exposure. This description constitutes a definition of byssinosis, which many of my colleagues and I adhere to. That is, byssinosis is a disease which starts with short lasting acute responses to dust exposure and may progress to chronic lung disease with more or less severe disability. There has been disagreement on the use of the term byssinosis. Some would want to limit the diagnosis to persons who have evidence of chronic lung impairment only. This, however, would detract from the urgent need to prevent the development of chronic lung disease, and we must focus an important part of our effort on those people who respond acutely to dust but who do not yet have irreversible lung damage.

This condition has been observed all over the world. In Belgium it was studied in some 2,000 cotton workers and was described as *Monday chest tightness* in the year 1845. I might add that already in 1837 a young New York physician, McCready, wrote a book on occupational

disease, and in it he made the remark that the New England cotton mills should do something about the dust in the workrooms. However, he did not elaborate on the reasons why he thought that this dust should be removed from the air.

The disease has been studied on all continents except Latin America. So far it ranges from Dr. Gandevia in Australia (who is here today), Dr. Shogo Shima in Japan, and others in India, Taiwan, and a number of African countries, several European countries, and to the United States and Mexico. In nearly all of these studies, a smaller or larger number of people have been diagnosed as having byssinosis. Many physicians have been involved in these studies and their results have been remarkably similar. In most of these countries the disease was identified in the industry by epidemiologists. It is a recurring pattern, whenever this disease occurs, that physicians in hospitals and clinics underestimate the prevalence of this disease.

The prevalence of byssinosis in the United States, studied in three mills, has been found to be rather similar in that some 20% to 30% of the people in the carding room are affected. The percentages of people in the spinning rooms vary more. There are technical reasons for this, but I won't go into these at this time. Two main points I want to make about these findings. In the first place I want to draw your attention to a mill in the Atlanta Federal Penitentiary, where some 100 men were exposed to dust for less than one year. Percentage prevalence of Monday symptoms of byssinosis was similar in that category and in the total numbers of workers. The total number of these workers, the duration of exposure to the dust, the number of years that people had worked in this environment was much less than in the two commercial mills, where people had on the average worked for 12 to 18 years. In all these areas the total

dust concentration, in milligrams per cubic meter, is not excessively high compared to what has been found in earlier studies. This is very likely related, at least in part, to what Richard Schilling has already shown you about the effect of lint removal from the air. In all these mills there were some systems to abate dust and it is likely that these machines did a rather good job in cleaning out the visible coarse dust that does not get into your lungs, but left in the air the invisible small dust that *does* get into your lungs. I should remind you that about the best air filters for small dust particles are our own lungs; they have so many very fine tubes where the circumstances for deposition of particles, less than 5 u in diameter, are really very excellent and these are much better filters than any of the mechanical devices that are currently used in most textile mills.

How can we detect this disease apart from asking the workers for their symptoms? One of the best ways of doing this is by having the worker blow hard into a spirometer, a measuring device for lung volume changes, before he starts work on a Monday and again before he goes home at the end of the shift. At the end of the Monday the value measured by this device [the forced expiratory volume in 1 second (FEV 1)] is lower than in the morning. The results of a group of cotton workers in Sweden provide data similar to that obtained in many cotton mills including those in this country. At the end of the day on Monday these people, on the average, have significantly lower values of their capacity to breathe out forcefully, and this decrease is larger in those who complain of Monday symptoms than in those who do not have such a history. This change means that somewhere along the airways there is some narrowing of the fine tubes that conduct the air to our lungs. The people who do not complain have a similar response as those who do. In other occupations, including coal mining and other dusty jobs, such a response does not occur. The

people in coal mining and other dusty jobs do not decrease their FEV 1 during exposure and likewise people in other occupations do not show such a response.

The decrease of FEV 1 in textile workers is caused by the dust they inhale. Those with the more severe drop of FEV 1 will complain of chest tightness; those with less severe responses may not complain.

Another way of looking at the same phenomenon is provided by the flow-volume curve. These are curves which I will interpret very simply by saying that the horizontal axis shows how much you can breathe out. The length of the horizontal portion of the curve is proportional to the volume one breathes out. The distance along the ordinate is proportional to how fast you can breathe it out. In other words, you have a sort of performance diagram of the lungs during expiration. Without going into the physiology of it, I would just like to state that the rapidity of expiration in a considerable proportion of this curve is quite unrelated to how hard you try. You have to deliver a minimum of effort but beyond that you will not improve the flow rates. These flow rates decrease markedly by the end of the work shift. An example is given, based on results in six representative workers. These flow rate decreases are caused by the narrowing of small airways in the lungs.

Let me describe two older textile workers. These men have been exposed to hemp dust for about 25 years or more and it illustrates what can happen. Two things can happen to someone who stays in this dust long enough. On the one hand, we have a man of 53 years who has a normal pulmonary function. His vital capacity is normal for his age and height. His flow rates are also normal for his age and height. This person has never experienced Monday symptoms of byssinosis while he worked in the dust. Unfortunately, such people

are in the minority. The other man is 59 years of age. His pulmonary function is severely decreased. His vital capacity is far too small, but much more important, his capacity to breathe out rapidly is severely disturbed. As a result this person is severely disabled. This man has experienced Monday symptoms of byssinosis all through his working life. Unfortunately, such people form a much larger proportion of an older population of these workers than do the non-reactors of which the first man is an example. There are many disabled cotton workers in the southern part of the United States. In 1966 Dr. Schilling and I spent altogether one week in the South and, with the aid of two physicians, we saw 14 cotton workers. Half of these were severely disabled by respiratory deficiency. I'm convinced that a more thorough and more systematic study would show this type of disability is prevalent wherever appreciable numbers of people have been exposed to cotton dust for many years. We have not yet been able to do such a thorough epidemiological study in the United States, but we have done this in Spain in a town where a large proportion of the population used to work in hemp dust.

Hemp workers and controls do not differ in the younger age category. The difference is highly significant in the older category where the hemp workers have a severely decreased FEV 1, which is quite significantly smaller than that in the control subjects who were living in the same area but who were not exposed to the dust. I might say that these control subjects are quite comparable in this respect to the data which has been obtained by several people in other populations, like Dr. Ferris in British Columbia. This type of data is pretty much the same wherever you do it unless there is some special factor at work, like in this case the hemp dust.

It has been asked, of course, what is the agent in the dust that causes this acute response which may lead in

a certain portion of cases to severe chronic lung disease. The bracts are the crumbling leaves around the stem that are dead long before the plant is harvested. When we make a very simple watery extract of these bracts, we can demonstrate certain effects on human lung tissue. In the laboratory we can also have this extract inhaled by healthy people. Two healthy investigators inhaled this extract of bracts for ten minutes. In this case we had boiled the bracts to determine whether or not the agent was heat stable. Both the subjects experienced chest tightness after this exposure. Both of them have a decrease of maximum flow rates—very similar to what one finds in the cotton and hemp workers exposed to the industrial dust. We believe that there is a pharmacological agent which is in the dust because the dust contains bract particles, broken up. A substance that is rather easily water-soluble, so that when dust hits your airways, this substance can transfer to the tissue and exert its toxic action. Whether this agent is the sole cause of the long term changes remains to be seen. It is also quite possible that apart from the one action of this agent, which we have identified, there are others which contribute to an action. So far, however, we have been unable to get similar data with any other part of the cotton plant we've tried, so for practical purposes I think that these leaves are very important. If they were not in the cotton dust we would very likely have much less of a problem. Control of this disease is obviously necessary and I'm sure that this is going to be mentioned by several speakers in this program and I don't want to preempt what they are going to say. I would like to emphasize, I think there are many good measures that can be taken on relatively short term at least to prevent poeple who are now at work in the industry from becoming disabled and those who may have some degree of irreversible decrease of pulmonary function from getting worse. I think this can be achieved by education, by pre-employ-

ment medical examination, and by periodical medical examinations. There are a number of common sense measures that can be taken to protect people who are in the industry. I'm sure that some people who are affected might be transferred to other jobs. This is not practical for all of them, obviously, and it is not practical for all of those who respond to dust. Also, there are drugs that can prevent the acute action of this dust, which might be used in suitable cases. On the long term, there is no substitute for suppression of the fine dust in the air. This is a very urgent matter, as Richard Schilling has also pointed out. Technology will have to be developed for getting rid of the fine dust which, so far as I am aware, has not been done in the textile industry on any large scale.

I think that a large amount of work has to be done, not only in this particular industrial lung disease, but in general in industrial lung diseases. My personal feeling and that of several of my colleagues is that as a cause of environmentally induced lung disease, industrial emissions are far more important than general air pollution as a cause of disability and death. They can be completely prevented and we don't have to wait for much further research in order to prevent the diseases. There is a lot that remains to be learned about these diseases, but there is also a serious lack of application of the knowledge that we have and we don't have to wait until all the answers are in before we can prevent people from becoming disabled by industrial lung disease.

The data on which this presentation is based has been published in the following papers:

Bouhuys, A., L. J. Heaphy, Jr., R. S. F. Schilling, and J. W. Wellborn. 1967. Byssinosis in the United States. New Eng. J. Med. *277*:170-175.

Bouhuys, A., R. L. Wolfson, D. W. Horner, J. D. Brain, and E. Zuskin. 1969. Byssinosis in cotton textile workers. Respiratory survey of a mill with rapid labor turnover. Annals Int. Med. *71*:257-269.

Zuskin, E., R. L. Wolfson, G. Harpel, J. W. Wellborn, and A. Bouhuys. 1969. Byssinosis in carding and spinning workers: Prevalence in the cotton textile industry. Arch. Environ. Health, *19*:666-673

The prevention and control of byssinosis and of industrial lung diseases have been discussed in:

Bouhuys, A. and J. M. Peters. 1970. Control of environmental lung disease. New Eng. J. Med. *283*: 573-582

Bouhuys, A., J. C. Gilson, and R. S. F. Schilling. 1970. Byssinosis in the textile industry; research, prevention and control. Arch. Environ. Health *21*: 475-478.

EXHIBIT 6-19

Braun, *et al.*, "Prevalence of Respiratory Signs and Symptoms Among U.S. Cotton Textile Workers"

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The workers who complain of tightness do not necessarily have a loss in $FEV_{1.0}$, or vice versa, as stated in the literature.

* * * * *

EXHIBIT 6-24

Bouhuys, *et al.*, "Byssinosis in Cotton Textile Workers"

* * * * *

No general agreement has as yet been reached on these questions. Our tentative answer to the first question is affirmative: If lung function tests show that airway obstruction develops in a worker during textile dust exposure, we view this as objective evidence that the dust affects his airways. For several reasons such persons may not always mention subjective symptoms of respiratory distress during a questionnaire interview. When interviewed on Monday after work, symptoms may be mentioned by men who denied them during a previous interview conducted at a time that they did not experience the dust effect (22). Secondly, some textile workers markedly dissimulate symptoms (23), possibly because of fear of losing their job. Thirdly, as in other diseases, the threshold of awareness of distress may vary individually. We believe that byssinosis should be diagnosed in all workers in whom evidence of an effect of textile dust on the lungs is obtained.

* * * * *

EXHIBIT 6-27

Bouhuys, "Breathing, Physiology, Environment and Lung Disease"

* * * * *

As a working hypothesis, one may assume that the repeated microinsults to the lungs that occur each time a worker is exposed to toxic dust, especially on Monday, have a cumulative damaging effect. The damage mechanism is not known. If the histamine release from mast cells during acute exposure involves damage to cell walls, this process might represent such a microinsult. Chronic lung damage might result from these and possibly other microinsults on the cellular elements, if regularly repeated during many years.

* * * * *

The practical significance of the functional grades (see Table 17-3) is as follows:

F 0: no demonstrable acute effect of the dust on ventilatory capacity; no evidence of chronic ventilatory impairment.

F ½: slight acute effect of dust on ventilatory capacity; no evidence of chronic ventilatory impairment.

F 1: definite acute effect of dust on ventilatory capacity; no evidence of chronic ventilatory impairment.

F 2: evidence of slight to moderate irreversible impairment of ventilatory capacity.

F 3: evidence of moderate to severe irreversible impairment of ventilatory capacity.

Increasing grades indicate increasing severity of functional impairment. F ½ and F 1 indicate acute dust

effects. Workers in grade F 1 should, if at all possible, be removed to jobs in nonrisk areas.

* * * * *

Table 17-3

Recommended Functional Grades in Byssinosis

Grade *	$\triangle$ $FEV_{1.0}$† (liters)	$FEV_{1.0}$ ‡ (% of predicted)
F0	−0.05-0; or +	>80
F½	−0.06- −0.20	>80
F1	>- −0.20	>80
F2	—	60-79
F3	—	<60

* If the grades based on $\triangle$ $FEV_{1.0}$ and $FEV_{1.0}$ differ, assign the highest of the two grades.

† Difference between $FEV_{1.0}$ before and after work shift on a first working day of the week.

‡ $FEV_{1.0}$ in the absence of dust exposure (2 days or longer); use value postisoproterenol whenever this drug can be used.

EXHIBIT 6-44

Merchant, *et al.*, "An Industrial Study of the Biological Effects of Cotton Dust and Cigarette Smoke Exposure"

Until recently, little awareness had been expressed in the U.S. medical literature about respiratory disease acquired from working in the cotton textile industry.

* * * * *

It is the purpose of this paper to describe and quantitate individual and combined effects of cotton dust and cigarette exposure as associated with byssinosis prevalence and four parameters of ventilatory capacity. Because of the constraint of time, only white males employed in preparation and yarn processing areas will be considered for statistical analyses.

Methods

Selection of the Population: Initially, a total of 22 North Carolina textile manufacturing plants were visited to determine the grade and count of yarn manufactured, plant layout, ventilation systems, machine exhaust systems and distribution of workers by sex, race, age and work area. Twelve plants processed primarily cotton, five cotton-synthetic blends and five either synthetic or wool material. Based on information gained through these visits and from a previous survey [4] which provided estimates on the distribution of smoking habits, three strata of exposure (cotton = high risk, cotton-synthetic blend = moderate risk, synthetic-wool = low risk) were selected for a three factor factorial design to fill adequately four categories of age (15-29, 30-39, 40-49, 50-70), sex and three categories of smoking habit (never smoked, current smoker, former smoker). Initially two plants at extremes of exposure were picked for the first two surveys. From these surveys better estimates of demographic characteristics and disease prevalence were sought to help select other plants to fill categories of the factorial de-

sign. Other selection criteria were age of the plant, whether it was associated with a mill village and proximity to other mills under consideration. At least thirty miles were allowed between plants.

Three cotton mills, all processing strict low middling cottons, were selected. Mill A processed cotton with a mean count of 6. Mill B with a mean count of 31, and Mill C with a mean count of 33 plus 25% synthetic material. Two cotton-synthetic blend mills processing primarily strict middling cottons were selected. Mill D processed 50% synthetic material and 50% middling cotton with a mean count of 29, and Mill E processed 49% synthetic and both strict low middling and middling cottons with a mean count of 32. The grade, count and mix of materials had been relatively constant in the few years preceding the study in all five cotton mills. Two synthetic processing mills, Mill G and Mill H, processed only synthetic material and one mill, Mill F, processed 100% wool. All had previously been cotton mills but none had processed cotton for more than 20 years. All mills selected had once been associated with a mill village.

Within each mill up to four primary work areas were defined. The preparation area included opening, blending, picking, carding, drawing, combing and roving. The yarn processing area included spinning, winding, twisting, spooling and warping. Slashing and weaving operations were combined to form a third primary work area. Other employees studied were those employed in the warehouse, shops, labs, supply areas, inspecting area, the yard and administrative personnel. None of these employees could be assigned a dust level since their dust exposure was intermittent and variable.

EXHIBIT 6-51

Merchant, *et al.*, "Dose Response Studies in Cotton Textile Workers"

There is evidence of awareness of the fundamental association between increased dust level and increased prevalence of respiratory disease among textile workers since early in this century when efforts were made to minimize disease through suppression of dust from the carding engine.[1] Although this concept of dose-response was appreciated, it was not quantitated until 1960 when Roach and Schilling [2] reported their study of the association between three fractions of cotton dust and its characteristic biological response. They found the strongest linear association between the protein content of the middle fraction of dust (7μ to 2mm-Hexlet) but also a strong linear correlation with total lint and dust. Because of this strong association with gross dust concentration and the simplicity and rapidity of sampling for total dust, they recommended 1 mg/m^3 gross dust as a reasonably safe level of occupational exposure. This recommendation was adopted by the American Congress of Government Industrial Hygienists and is the current threshold limit value for cotton dust.[3]

Roach and Schilling recognized that some fine dust ($< 7\mu$) and medium dust (7u-2mm) was trapped on the lint mat collected on the 2 mm screen, which may have reduced the correlation coefficients for these fractions.[2 4] Subsequent observations showed that the fine fraction of dust ($< 7\mu$) could account for nearly all of the prevalance of byssinosis,[5 6 7] and that gross dust levels, particularly in yarn processing areas (spinning, winding, twisting) could be misleading indicators of biological effect.[8 9 10] In recognition of these findings, new standards for safe levels of cotton dust exposure are being considered in Great Britain and the United States.

The study described in this paper offered the opportunity to observe biological effects in a large working popula-

tion over a wide range of dust exposure. The primary objectives of this portion of the study were to evaluate the vertical elutriator cotton dust sampler and to develop dose-response relationships to help establish the safe level of exposure to lint-free cotton dust.

Methods

Definitions, the study design, and methods used in collecting data are found in the Methods section of the preceding paper.[11] As previously described, each worker was assigned a mean, median and a geometric mean dust level of his work area which was used to develop dose-response curves. Although little difference was apparent in these three measures of central tendency (Table 1), the median

Table 1.—Vertical Elutriator Dust Samples by Mill Type, Work Area, Measures of Central Tendency and Range North Carolina, 1970-71

Mill Type	Work Area			
	Preparation	Yarn	Slash/Weave	Total
Cotton				
Dust Samples, n	260	131	102	493
Workers, n	215	494	367	1076
Mean	.899	.303	.985	.654
Median	.669	.257	.798	.485
Geometric Mean	.639	.201	.828	.411
Range	.090-3.56	.013-1.30	.227-2.74	.013-3.56
Blend				
Dust Samples, n	130	61	46	237
Workers, n	164	398	146	708
Mean	.264	.122	.682	.270
Median	.163	.088	.683	.163
Geometric Mean	.194	.097	.666	.169
Range	.006-1.37	.006-.715	.292-.959	.006-1.37
Synthetic-Wool				
Dust Samples, n	134	121	—	255
Workers, n	212	586	—	798
Mean	.269	.157	—	.191
Median	.238	.186	—	.186
Geometric Mean	.232	.114	—	.138
Range	.017-.733	.013-.847	—	.013-.847

dust level was chosen because it reduced the effect of outliers and provided the best distribution of the population.

Mathematical dose-response curves were fitted to data on byssinosis prevalence by median dust level. Six groups of workers (Table 2), including black and white men and

Table 2.—Six Worker Groups by Smoking Status

Group	Smoking Status	Byssinosis Grades	Exposure
1.	Current Smokers	Grade ½, 1, 2	Cotton/blend mill preparation and yarn areas
2.	Never Smoked	Grade ½, 1, 2	Cotton/blend mill preparation and yarn areas
3.	All Workers	Grade ½, 1, 2	Cotton/blend mill preparation and yarn areas
4.	All Workers	Grade ½, 1, 2	Cotton/blend mill slashing and weaving areas
5.	All Workers	Grade 2	Cotton/blend mill preparation and yarn areas
6.	All Workers	Grade 1 and 2	Cotton/blend mill preparation and yarn areas

women, in two primary exposure areas (primarily cotton dust and cotton dust plus sizing) by smoking status are considered:

Raw data was categorized by arbitrary dust level groups to provide a wide and balanced (as well as possible) distribution of workers by dust level (Tables 3, 4). Because the number of workers above 1 mg/m^3 represented less than five percent of the total population and was therefore likely to result in unstable rates, and because those exposed to these high dust levels were likely to be a select, relatively more resistant group of workers, they were eliminated from consideration for calculation of linear regressions (except for Group 4). The truncated regression plots and correlation coefficients are displayed for this data in Figs 2, 3 and 4.

Table 3.—Demographic and Smoking Characteristics of Preparation and Yarn Processing Workers in Cotton and Blend Mills by Median Dust Level

Dust Level	0 to .056	.057 to .0838	.0839 to .1254	.1255 to .1877	.1878 to .2808	.2809 to .4201	.4202 to .6286	.6287 to .9404	.9405 to 1.407	1.408 to 2.105
Men										
n	70	34	104	144	61	122	69	65	30	42
Mean Age	39.5	36.9	38.7	42.1	33.6	37.8	38.8	37.1	41.4	38.7
% Current Smokers	67.1	64.7	56.7	54.9	73.8	53.3	73.9	55.4	73.3	66.7
% Former Smokers	14.3	23.5	19.2	22.2	9.8	18.0	10.1	16.9	13.3	14.3
% Black	5.8	8.8	7.7	19.0	26.2	29.2	27.5	36.9	13.3	64.3
Women										
n	75	37	89	135	17	85	77	0	1	0
Mean Age	41.5	43.9	44.4	42.9	39.6	38.8	37.7		21.0	
% Current Smokers	44.0	32.4	25.8	36.3	47.1	36.5	32.5	0	0	0
% Former Smokers	12.0	0	4.5	6.7	5.9	12.9	10.4	0	0	0
% Black	19.2	10.8	5.6	17.9	52.9	16.9	27.3	0	100.0	0

Percent change in $FEV_{1'0}$ with six hours of dust exposure for cotton/blend mill preparation and yarn area workers and synthetic/wool mill workers by dust level is shown in Table 5. Linear regressions truncated at 1 mg/m^3 were calculated and the regression lines and correlation coefficients shown in Figure 6.

Kenneth A. Busch, National Institute for Occupational Safety and Health, analyzed prevalence data using a probit model,[12 13] and developed Table 6 through 9 and the probit curves in Figs 2 through 4. His protocol for analysis was as follows: For each set of data, the method of maximum likelihood was used to fit a straight line to Y= probit (prevalence ratio) vs. X= $\log_{10}$ (median dust level in mg/m^3). A chi-square goodness-of-fit test was made to test jointly for both nonlinearity and excessive variance about the fitted curve as compared to theoretical results expected under the probit model. Ninety-five percent statistical confidence limits were put upon the true

dose-response curve as well as upon predicted dust levels corresponding to eight arbitrary levels of hypothetical byssinosis prevalence: p= 1%, 2%, 3%, 4%, 5%, 10%, 25,% and 50%. Pairs of curves for Groups 1 and 2, and for Groups 3 and 4, respectively, were tested for parallelism and, if found to be parallel, a "relative toxicity" metameter R was estimated along with its 95% confidence limits. By "relative toxicity" is meant the ratio between dust levels which produce the same prevalence of byssinosis in the two groups. Thus an R-value of 1.0 would imply the two curves were coincident. When curves for two groups are found to be non parallel, the difference between them is difficult to interpret since relative toxicity would not be constant at all levels of response. In such a case, a conditional relative dose metameter Rp was calculated for several p-levels of prevalence of byssinosis in the two groups.

Results

Table 2 summarizes 985 vertical elutriator (Fig 1) dust samples by mill type, work area, measures of central tendency and range. The greatest number of samples was collected in the preparation areas of the cotton and blend mills. The highest dust levels are recorded in the slashing and weaving areas of cotton and blend mills where sizing is used and contributes to the dust concentration. Where sizing is not used, the dust levels in the preparation area were consistently much higher than in the yarn processing areas. The mean dust levels were generally higher than the median or geometric mean levels, reflecting the effect of high out-liers. In synthetic and wool mills there was little difference in dust level between preparation and yarn processing areas. The highest dust levels in these mills were found in the preparation area of the wool mill and the preparation area of a synthetic mill where gasoline driven machinery was used.

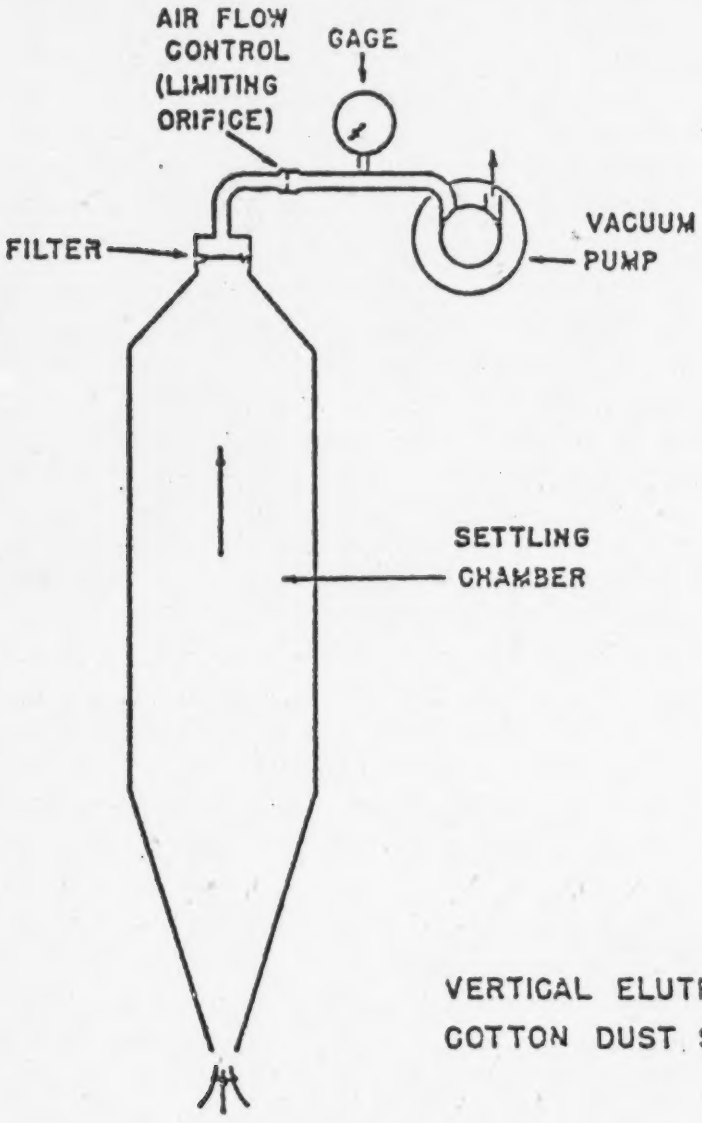
Demographic and smoking characteristics for men and women in cotton preparation and yarn areas by dust level are shown in Table 3. No clear age trend is apparent among men or women, nor is there a consistent difference in the proportion of current or ex-smokers between dust subgroups. Among men, a greater precentage of blacks were found with increasing concentration of dust exposure. This was less apparent among women who rarely work in the dustiest areas of the mills.

Busch concluded from his analysis that the log-probit model fitted the data well in every case. The points were scattered randomly about the fitted dose-response curve and the variance of deviations from the curve was not significantly greater than would be expected based upon an assumption of binomially-distributed prevalence ratios at each dust level.

Slopes (b) and intercepts (a) of the fitted log-probit dose-response curves, $Y = a + bx$, are shown in Table 6 together with three calculated points (ordinates Y) for each fitted curve and their 95% confidence limits. The curve equation was then inverted to predict dust levels corresponding to arbitrary prevalence levels. Table 7 shows the predicted dust levels and their 95% confidence limits for the six groups of workers for prevalence levels of 1%, 2%, 3%, 4%, 5%, 10%, 25% and 50%.

Chi-square tests for goodness-of-fit of the individual curves and for parallelism of pairs of curves (1 vs. 2 and 3 vs. 4) are shown in Table 8. Curves for current smokers (Group 1) and those who never smoked (Group 2) were found to be significantly different although nearly parallel but not coincident. A relative toxicity of $R = .56$ with 95% confidence limits of $R = .35$ to $R = .83$ was found (Table 8); this suggests that only 56% (35% to 83%) as much cotton dust is associated with any given prevalence of byssinosis among smokers as among

those who never smoked. Curves for all prepartion and yarn workers (Group 3) and for all slashing and weav-



VERTICAL ELUTRIATOR
COTTON DUST SAMPLER

- Fig 1.

ing workers (Group 4) were not found to be parallel. Therefore a single R-value was meaningless and it was necessary to calculate R_p-value as a function of eight arbitrary prevalence levels which are shown in Table 8. Curves for Groups 3 and 4 were found to be significantly different but yielding R_p-values which ranged from .087 at a byssinosis prevalence of 1% to .56 at a prevalence of 50%. Therefore, only approximately 9% (4% to 15%) as much cotton dust is associated with a 1% byssinosis prevalence for workers in the preparation and yarn areas of cotton mills as compared to the amount required for the same prevalence for cotton slashing and weaving workers. At a prevalence of 5% an average of 15% as much dust is required, as a prevalence of 25%, 32% as much, and at the 50% prevalence level 56% as much dust is required.

The probit-dose response curves are shown in Figs 2, 3, 4, together with the linear regression plots and correlation coefficients. The truncated linear plots are observed to fall within the 95% confidence limits of the probit curves below a dust level of 0.5 mg/m³. Both dose response curves for cotton slashing and weaving workers fell nearly on the same line through 2.0 mg/m³ of dust. The strength of the linear association between dust level and byssinosis prevalence was uniformly high except for those who had never smoked (Group 2) where the correlation coefficient was .52; however, one subgroup within this population contained only seven workers, none of whom had symptoms of byssinosis. Expected byssinosis prevalence levels are shown in Table 6 and the curves plotted for Groups 3, 5 and 6 in Figure 4. Prevalence of Grade 2 byssinosis (Group 5) ranges from 1.3% (0.7-2.3) at 0.1 mg/m³ to 3.0% (2.1-4.3) at 0.2 mg/m³ to 8.0 (6.1-10.2) at 0.5 mg/m³, as computed from the probit curve. When Grade 1 and 2 byssinotics are combined (Group 6) the probit prevalence levels are 2.1% (1.3-3.3) at 0.1 mg/m³, 5.0% (3.9-6.6) at 0.2 mg/m³ and 13% (10.7-15.8) at 0.5 mg/m³.

Table 5 and Fig 5 show percent change in $FEV_{1.0}$ with increasing levels of exposure among cotton preparation and yarn area workers and synthetic and wool workers. The truncated linear regression (Fig 5) for the cotton population again showed a strong linear association ($r = .82$) between biological effect and dust level. No decrement in percent changes in $FEV_{1.0}$ is seen with increasing levels of exposure to synthetic and wool dust.

Discussion

Dust Sampling.—In the year preceding this study, several cotton dust sampling techniques were evaluated.[14] The sampling device desired was to be relatively easy to operate, portable, durable, operable unattended for a full shift and provide a lint free dust sample. Of the sampling devices evaluated, the vertical elutriator developed by Lynch and Lumsden [14] was found to best fulfill these criteria. The instrument was designed to sample dust with a mass median aerodynamic diameter of 15μ and less which effectively eliminated biologically inert lint while retaining particles of the size expected to be inhaled. Since high correlations between byssinosis symptoms and dust level have been observed with the middle fraction (7μ to 2mm) of dust, [2 15] it was thought that larger particles (7μ-15μ) as well as "respirable" particles ($<7\mu$) should be collected. An added practical advantage of including larger particles is the accumulation of a weighable sample in a shorter interval. A potential disadvantage was the possibility of including fine but inert "linters" in the sample. This has been observed rarely in our experience and appears to occur only under the dustiest of conditions when exact dust levels are not as important.

In the absence of a specific assay for the etiological agent(s) responsible for the biological effects of cotton dust, the most important consideration in evaluating a

Table 4.—New Data on Byssinosis Prevalence vs. Median Dust Levels for Six Groups of Workers

Mid-Point * of Range of Median Dust Levels (mg/m^3)	Sample Size n	Cases of Byssinosis r	Prevalence (%) p = r/n x 100
Group 1. Cotton Preparation and Yarn Areas All Grades—Current Smokers			
.05	167	10	6.0
.15	159	21	13.2
.25	82	14	17.1
.35	64	14	21.9
.45	55	15	27.3
.55	26	11	42.3
.75	31	16	51.6
1.1	12	5	41.7
1.5	12	7	58.3
1.9	26	12	46.2
Group 2. Cotton Preparation and Yarn Areas All Grades—NonSmokers			
.15	127	3	2.4
.15	145	9	6.2
.25	44	2	4.5
.35	54	16	29.6
.45	49	12	24.5
.55	7	0	0
.75	18	5	27.8
1.1	2	0	0
1.5	3	2	66.7
1.9	8	3	37.5
Group 3. Cotton Preparation and Yarn Areas All Grades—All Workers			
.0458	145	5	3.4
.0686	71	2	2.8
.1026	193	14	7.3
.1535	279	27	9.7
.2296	78	10	12.8
.3435	208	39	18.8
.5139	147	37	25.2
.7689	65	30	46.2
1.150	31	14	45.2
1.722	42	17	40.5

* Arithmetic mean of end-points used for groups 1, 2, 4.

Geometric mean of end points used for groups 3, 5, 6.

Table 4.—Continued

Mid-Point * of Range of Median Dust Levels (mg/m^3)	Sample Size n	Cases of Byssinosis r	Prevalence (%) p = r/n x 100
Group 4. Cotton Slashing and Weaving Workers All Grades—All Workers			
.35	15	1	6.7
.45	136	7	5.1
.55	2	0	0
.75	195	14	7.2
1.1	34	6	17.6
1.5	87	23	26.4
1.9	44	16	36.4
Group 5. Cotton Preparation and Yarn Areas Grade 2			
.0458	145	0	0
.0686	71	1	1.4
.1026	193	2	1.0
.1535	279	9	3.2
.2296	78	1	1.3
.3435	208	8	3.8
.5139	147	14	9.5
.7689	65	11	16.9
1.150	31	6	19.4
1.722	42	6	14.3
Group 6. Cotton Preparation and Yarn Areas Grades 1 & 2			
.0458	145	0	0
.0586	71	2	2.8
.1026	193	2	1.0
.1535	279	11	3.9
.2296	78	2	2.6
.3435	208	23	11.1
.5139	147	22	15.0
.7689	65	15	23.1
1.150	31	8	25.8
1.722	42	9	21.4

* Arithmetic mean of end-points used for groups 1, 2, 4.
Geometric mean of end points used for groups 3, 5, 6.

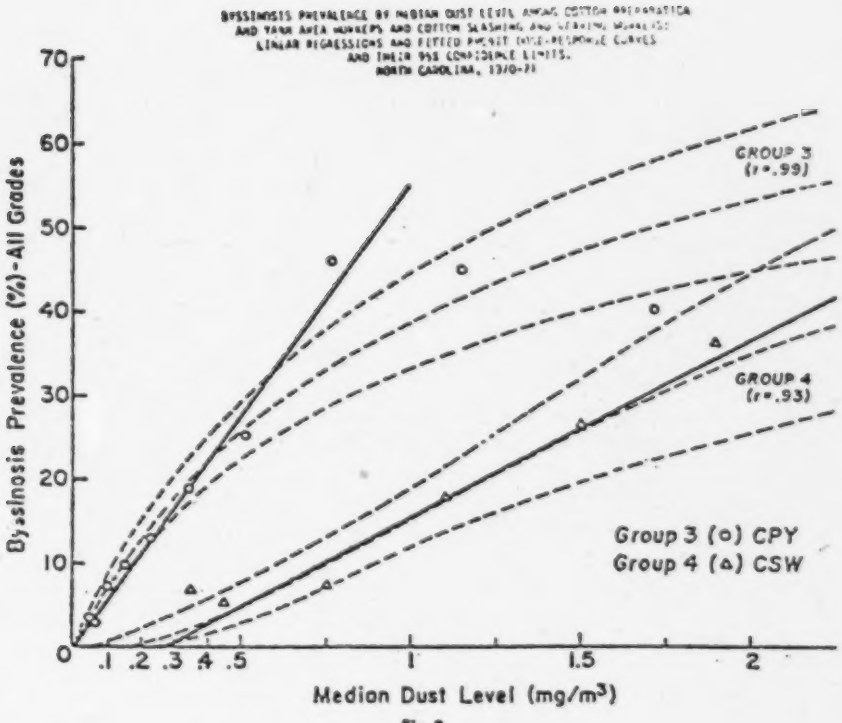


Fig-2.

gravimetric sampling technique is the degree of correlation with biological indicators over the range of exposure. As shown in Figs 2 through 5, a strong linear association was found in this population, particularly below 0.5 mg/m³, the level below which the majority of the population is exposed and where attention is focused concerning establishment of a reasonably safe exposure level.

As a field instrument the vertical elutriator cotton dust samplers have proven to be most practical and durable. The 25 samplers built for this survey have now been in use for two years and have collected over 3000 samples. No modification of the instrument or the sampling procedure has been necessary. Its design lends itself to use within the manufacturing plant; at no time has it

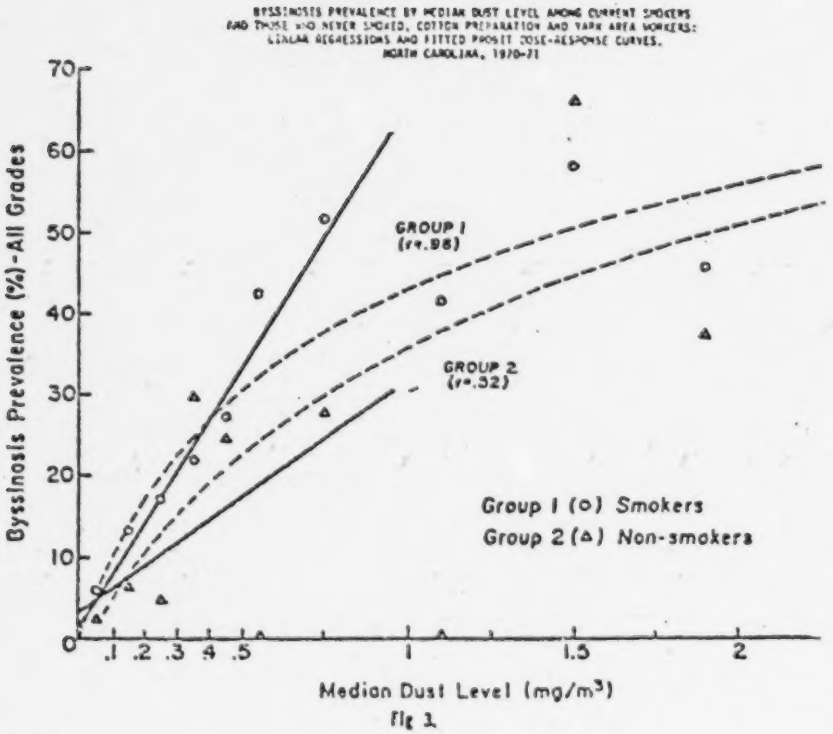


Fig 1.

interfered with the manufacturing process or personnel. Sampling with this instrument can easily be learned and could be used by manufacturing personnel to monitor their working environment.

Dose-Response.—In developing dose-response curves for byssinosis, tables were developed by sex, smoking groups, work areas (preparation, yarn production and slashing/weaving) and mill type (cotton and blend). A strong linear association was repeatedly observed in these subpopulations. Since there appeared to be no difference in age between individual dust level subgroups (Table 3), there was no reason to age adjust the data. Similarly, no difference in byssinosis prevalence has been found in men and women, allowing both to be considered together.

Preparation and yarn processing areas are justifiably combined since the dust is of the same composition, the dose-response curves for each area are similar, and the areas are frequently continguous. When the yarn arrives in the slashing department, sizing is added to the yarn and has been found consistently to increase the concentration of lint free dust in the slashing and weaving areas. Therefore, the biologically active airborne material in these workrooms is diluted with biologically inert sizing, making it necessary to consider this dust separately when considering these significantly different dose-response relationships. Cigarette smoking has been found to significantly increase byssinosis prevalence [9 11 16 17] and must therefore be considered a potential source for a secondary association. Table 3, however, shows no apparent difference in smoking habits between dust level sub-populations. Probit analysis revealed that byssinosis prevalence for smokers was significantly higher than for non-smokers. Although it may be argued that the most susceptible group (smokers) should be most closely considered when recommending safe levels of exposure, the majority of this working population smoke cigarettes and the dose-response curves for current smokers and all workers regardless of smoking habit are similar. For this reason, and because a standard generally applies to the entire population at risk, consideration of the entire population regardless of smoking habit appears to be most appropriate.

As initially observed by Roach and Schilling,[2] and later confirmed by El-Batawi,[18] Molyneaux,[15] and our group in an independent study,[19] dose-response curves for the association between dust level and byssinosis prevalence and/or change in FEV_{10} are strikingly linear. This was found repeatedly in this data no matter how the groups were divided, unless the number of workers in the dust level sub-populations was so low as to produce unstable rates

(Group 2, r = .52, Fig 3). With this exception, correlation coefficients were consistently above 0.9. Similarly, the association between percent change in FEV_{10} and median dust levels was also strong (r = .82, Fig 5). A source of increase variance in this measurement is diurnal variation in expiratory flow rate which was observed but not adjusted out. The distribution of workers by shift within dust level sub-populations was similar and therefore unlikely to produce a secondary association. Above a median dust level of 1 mg/m^3 the dose-response curves tend to flatten. We suspect that selection, leaving relatively resistant workers in these dustier areas, is responsible for this decrease in prevalence and percent change in $FEV_{1.0}$. As reviewed in the preceding article, there is substantial evidence of selection away from dust exposure in this industry.[9 20 21] In Table 3, a consistent trend toward a higher percentage of black men was found with increasing dust level. Blacks have been found to have lower rates of chronic bronchitis than whites of

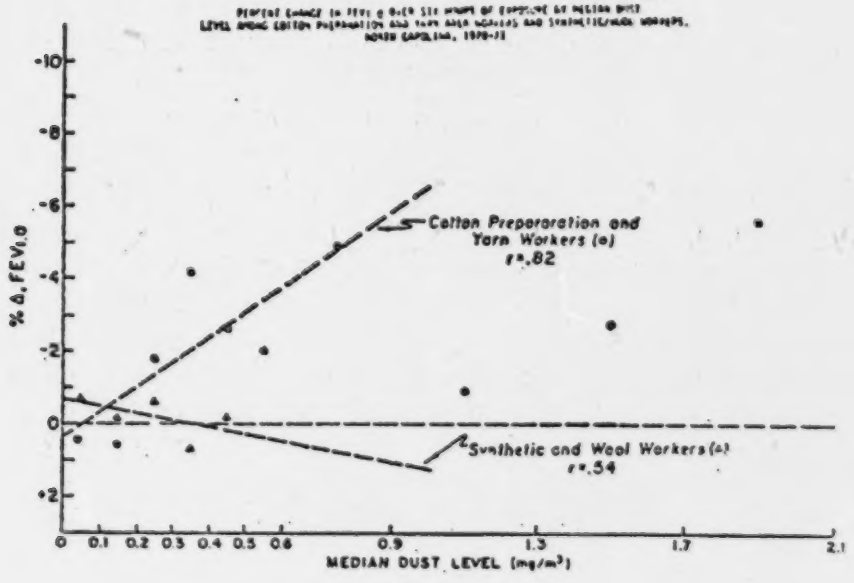


Fig 4.

Table 5.—Raw Data on Percent Change in $FEV_{1.0}$ vs. Median Dust Level among Preparation and Yarn Area Workers in Cotton/Blend Mills and Workers in Synthetic/Wool Mills

Mid-Point of Range of Median Dust Levels (mg/m^3)	Cotton/Blend Mills			Synthetic/Wool Mills		
	n	mean $\%\triangle FEV_{1.0}$	S.D.	n	mean $\%\triangle FEV_{1.0}$	S.D.
0.05	299	0.4	9.4	241	0.7	5.5
0.15	309	0.5	9.8	212	0.2	7.0
0.25	113	−1.8	10.0	141		6.7
0.35	130	−4.2	6.1	112	0.7	7.0
0.45	95	−2.6	16.2	7	0.2	3.3
0.55	35	−2.0	8.8			
0.75	61	−4.9	10.1			
1.10	16	−0.9	10.3			
1.50	12	−2.7	6.0			
1.90	35	−5.6	10.9			

Table 6.—Parameters of Log 10-Probit Dose-Response Curves and Three Points on Each Fitted Curve with Their 95% Confidence Limits

Group	Intercept (a)	Slope (b)	Expected Prevalence (%) .1 mg/m^3	.2 mg/m^3	.5 mg/m^3
1	4.826	1.108	10.0% (7.3-13.3)	17.1% (14.2-20.5)	30.6% (25.9-35.6)
2	4.641	1.301	4.9% (2.8-7.9)	10.2% (7.5-13.6)	22.7% (17.0-29.3)
3	4.718	1.226	6.5% (5.0-8.5)	12.7% (10.8-14.9)	25.8% (22.5-29.3)
4	3.966	2.134	0.08% (0.01-0.7)	0.6% (0.1-2.1)	4.7% (2.7-7.7)
5	3.944	1.170	1.3% (0.7-2.3)	3.0% (2.1-4.3)	8.0% (6.1-10.2)
6	4.269	1.304	2.1% (1.3-3.3)	5.0% (3.8-6.6)	13.0% (10.7-15.8)

the same age and environmental exposure.[22] The relatively greater number of blacks with relatively lower response at high dust levels in this textile population may represent another example of ethnic difference in susceptibility to the biological manifestations of inhalants. Further analyses of this data are being done to determine whether this is a sociological or a biological problem.

Another important observation concerning these dose-response curves is that there appears to be no threshold beneath which no one with Monday chest tightness was found (Table 4). This indication that low dust concentrations result in measurable effects suggests that cotton

Table 7.—Predicted Dust Levels and Their 95% Confidence Limits for Arbitrary Levels of Prevalence of Byssinosis

Prevalence	Predicted Dust Level (mg/m3)					
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
1%	.011 (.004-.022)	.031 (.010-.056)	.021 (.012-.033)	.25 (.12-.36)	.082 (.042-.12)	.060 (.034-.085)
2%	.020 (.008-.035)	.050 (.020-.081)	.036 (.021-0.51)	.33 (.19-.45)	.14 (.086-.19)	.097 (.063-.13)
3%	.029 (.013-.047)	.068 (.031-.10)	.050 (.032-.068)	.40 (.25-.52)	.20 (.13-.26)	.13 (.091-.17)
4%	.038 (.019-.059)	.085 (.044-.12)	.063 (.043-.084)	.46 (.31-.58)	.25 (.18-.33)	.16 (.12-.21)
5%	.047 (.025-.071)	.10 (.057-.15)	.077 (.054-.10)	.52 (.36-.64)	.31 (.24-.41)	.20 (.15-.25)
10%	.10 (.065-.14)	.20 (.14-.26)	.15 (.12-.18)	.77 (.62-.90)	.64 (.49-.93)	.38 (.31-.46)
25%	.35 (.28-.47)	.57 (.41-.97)	.48 (.40-.59)	1.5 (1.2-1.9)	2.1 (1.4-4.6)	1.1 (.84-1.6)
50%	1.4 (.97-2.6)	1.9 (1.1-5.5)	1.7 (1.2-2.7)	8.1 (2.2-5.4)	8.0 (3.9-28.5)	3.6 (2.3-7.4)

dust is a highly biologically active inhalant. British studies reported by Molyneaux and Berry [15] also found no threshold for the biological effects (byssinosis and simple bronchitis) of respirable dust ($<7\mu$-Hexlet) and middle fraction dust (7μ to 2mm-Hexlet). Although these dust fractions and the vertical elutriator dust fraction are not strictly comparable, they do contain much of the same dust distribution. When their dose-response regressions are plotted with those presented in this paper, there is good general agreement both in origin and slope. At 0.2 mg/m^3, both sets of curves reveal roughly 15% with some grade of byssinosis. As has been observed before, surprising uniformity in byssinosis prevalence has been found in cross-sectional surveys despite differing populations, working conditions, and frequently somewhat different methods of study.

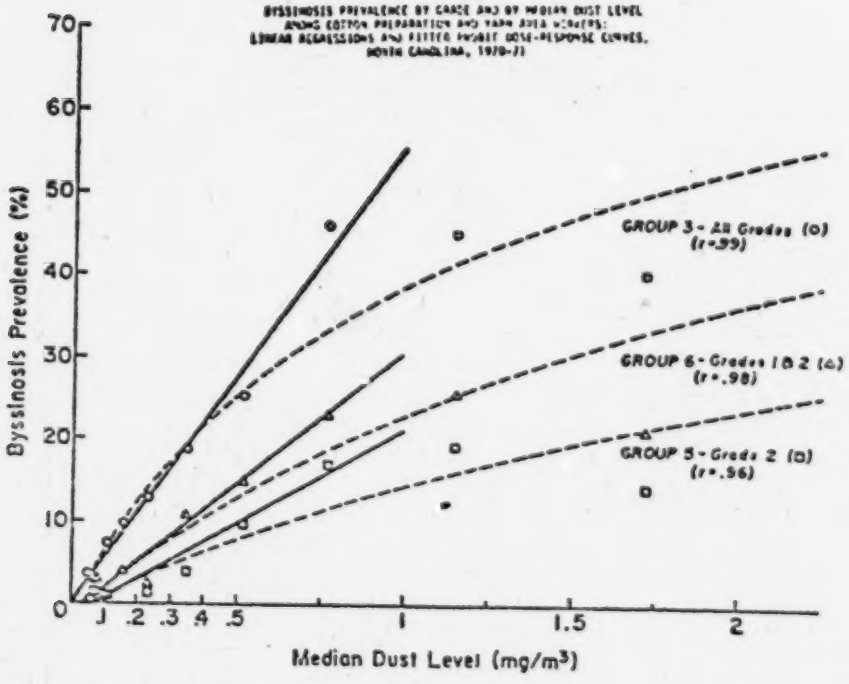


Fig 5.

Table 8.—Chi-Square Tests for Goodness-of-Fit of the Log-Probit Model and for Parallelism of Pairs of Fitted Lines.

Group	Goodness-of-Fit x^2	df	P	Parallelism x^2	df	P
1	6.0	8	.65			
2	14.1	8	.08			
3	7.5	8	.52			
4	3.8	5	.58			
5	8.3	8	.60			
6	10.0	8	.26			
1 & 2	20.1	16	.21	0.53	1	.47
3 & 4	11.3	13	.59	6.0*	1	.015

Symbols: df = degrees of freedom

P = probability of x^2 as large or larger than observed value

* = significant at the .05 probability level

Table 9.—Relative Toxicities and Their 95% Confidence Limits

Byssinosis Groups	Prevalence P	Relative Toxicity R	95% Confidence Limits
1 & 2	All levels	.56	.35 to .83
3 & 4†	.01	.09	.04 to .17
	02	.11	.06 to .19
	.03	.12	.08 to .20
	.04	.14	.09 to .21
	.05	.15	.10 to .22
	.10	.20	.15 to .26
	.25	.32	.24 to .43
	.50	.56	.32 to .96

Symbols: P = No. of subjects with byssinosis/total No. of subjects

R = ratio of dust levels producing same prevalence (eg., dust level for group 1/dust level for group 2)

† = Note: Dose response curves for groups 3 and 4 are non-parallel, so that relative toxicity varies with level of prevalence

The log-probit model was found to fit this data well and offers the opportunity to consider prevalence at fixed dust levels and conversely, calculate dust levels from any given level of prevalence. This is clearly very useful when considering data for setting standards. Probit analysis (Table 6) shows the expected byssinosis prevalence for all grades of byssinotics at 0.2 mg/m^3 to be 12.7%, while only 3.0% for Grade 2 byssinotics. In order to determine what a reasonably safe level of lint free dust might be, the question is raised whether all grades of byssinosis or only Grade 2 byssinosis prevalence is the appropriate indicator. We concluded that overall byssinosis prevalence best estimated byssinosis risk since it was likely to be less affected by selection than Grade 2 byssinosis. In our experience, workers usually do not consider selecting themselves out of exposure if they have only occasional chest tightness or tightness which is not severe and confined to Monday. Those with tightness on Monday and other days (Grade 2) frequently also complain of dyspnea and fatigue; as a result it is not uncommon to find that these workers request a change in job location. Therefore, those with Grade 2 byssinosis symptoms are likely to represent a highly selected group which would very likely result in an underestimation of risk.

Also to be considered is the sensitivity of the biological indicators used in this study; the standard indicators in studying the effects of cotton dust have been byssinosis symptoms and change in $FEV_{1.0}$. There is now evidence that use of flow-volume loops [9 23 24] and measurement of the leukocyte response [24] increase sensitivity in detecting biological effects. Therefore, because of selection and because the indicators of response in developing this dose-response data although well standardized are probably still dull tools, we conclude that, for cotton and blend mill preparation and yarn areas, a reasonably safe level of cotton dust exposure is 0.1 mg/m^3. Even at this low level an expected byssinosis prevalence of 6.5% was found by

probit analysis. A separate level of 0.75 mg/m^3 is suggested as a reasonably safe level in slashing and weaving areas. It will be necessary to include in any cotton dust standard provisions for periodic testing of workers to detect those most susceptible and to avoid placement of those with impaired lung function in dusty areas.

Dust Control.—There is now substantial evidence that biological effects result from low levels of lint-free cotton dust exposure, even with relatively crude indicators of response. To make the cotton textile mill working environment reasonably safe, very great strides must be taken in controlling fine dust. Initially, this requires a reorientation in thinking regarding dust handling from suppressing primarily lint to suppression of fine dust as well. Currently, machine exhaust and ventilation and filtration systems are designed primarily to control lint and large dust particles and not fine dust. As a result, the workroom frequently appears lint free and relatively clean, yet lint free dust levels may be relatively high. To solve this problem, two basic approaches may be taken. One is the traditional approach of dust control after the dust has been introduced into the mill; the second is removal of dust from lint prior to manufacturing. Clearly, the most desirable approach would be a method to harvest cotton without contamination with trash. New methods to improve picking are now under consideration. Dust reduction at the ginning stage would be the next most desirable location to control dust. There is now experimental evidence that the application of steam to cotton is compatible with manufacturing and reduces lint free dust levels and biological activity by roughly one half.[19] A plant wide intervention trial is now underway to test the effectiveness of steaming under manufacturing conditions. The feasibility of steaming cotton at a gin is also being tested. Although steaming may provide improvement in environmental conditions, it is apparent that

much improved dust control, particularly in preparation areas will also be required.

Table 2 shows that lint free dust levels are particularly high in the preparation areas of cotton mills. Review of dust levels from six cotton mills (three from this study; 670 samples) revealed vertical elutriator median dust levels of 1.50-1.59 mg/m^3 in opening and blending areas, 1.60-1.69 mg/m^3 in picking areas, 1.70-1.79mg/m^3 in carding areas, then dropping to 0.70-0.79 mg/m^3 in drawing, 0.40-0.49 mg/m^3 in roving, 0.20-0.29 mg/m^3 in spinning, winding and twisting, and then up again in weaving to 1.00-1.09 mg/m^3. In eleven blend mills (50% cotton or less), two of which are part of the study reported in this paper, 1232 vertical elutriator dust samples found a median dust level of 0.30-0.39 mg/m^3 in opening and blending, 0.50-0.59 mg/m^3 in picking, 0.60-0.69 mg/m^3 in carding, 0.30-0.39 mg/m^3 in drawing, 0.10-0.19 mg/m^3 in roving, 0.00-0.09 mg/m^3 in spinning. 0.10-0.19 mg/m^3 in winding and twisting and 0.50-0.59 mg/m^3 in weaving areas.[10] In these eleven blend mills, the spinning and weaving areas show median dust levels that may be considered reasonably safe and levels in roving, winding and twisting approach this level. Since less than 10% of the work force is employed in areas preceding roving, roughly 90% of those working in these eleven blend mills could be considered as working in a reasonably safe or marginally safe working environment. Those remaining, although exposed to hazardous dust levels, are working in a third or less the dust concentration of their counterparts in cotton mills.

By contrast, it appears from these figures that there is no work area in the cotton mills that could be considered reasonably or marginally safe, although yarn processing and weaving areas are not far from these levels. The areas clearly in acute need of attention are those of opening, blending, picking and carding. Because drawing

and roving are almost invariably in the same work area as the carding engine, much of the dust exposure in these latter two areas probably arises from the carding engine. To protect these workers, the carding area should be partitioned from drawing and roving and each area provided with an independent ventilation system. Under such conditions the dust levels in drawing and roving are expected to more closely approximate those in spinning. Close attention to recirculation of lint free dust ($< .05$ mg/m^3)[25] should further reduce dust levels to more acceptable levels. Preprocessing removal of fine dust by steam may also contribute to achieving safe levels in these areas. But even if steaming were to reduce dust levels by a half, the processes of opening, blending, picking and carding will require efficient exhaust systems. Fortunately, in each of these machines, the area in which the fiber is most vigorously processed is in a relatively enclosed part of the machine. Further enclosure of each of these machines with well designed exhaust systems does not appear to be insurmountable. Efficient removal of fine dust, without recirculation, should markedly improve these preparation areas and perhaps could also remove some dust which previously was released from the yarn in subsequent processes, thereby contributing to control in these work areas.

In summary, the following statements can be made:

1. This study confirms the finding of others, that a strong linear association exists between prevalence of byssinosis and decrement in expiratory flow rate with concentration of lint free dust.

2. The log-probit model, curves of which followed the linear regression plot below 0.5 mg/m^3, fit this data well and provided both expected byssinosis prevalence and conversely expected dust levels, both of which proved to be useful in interpretation of the dose-response relationship.

3. Based on these curves, it is concluded that a reasonably safe level of lint free cotton dust is 0.1 mg/m^3, a level at which nearly 94% of the population exposed were found to have no symptoms of byssinosis. A separate level of 0.75 mg/m^3 is suggested for slashing and weaving areas.

4. Probit dose-response curves for smokers and those who never smoked, showed that smokers had a signficantly higher prevalence of byssinosis.

5. The vertical elutriator cotton dust sampler, over a period of two years, has proven to be a durable and practical instrument which collects a biologically active lint free fraction of dust linearly associated with indicators of biological response.

6. Lint free dust levels by work area suggest that no work areas in the cotton mills sampled had reasonably safe dust levels and that the areas of opening through carding had very high levels. By contrast, in blend mills all areas beyond drawing had reasonable safe or marginally safe dust levels while levels preceding roving are considered only moderately elevated.

7. It is recommended that carding machines be isolated from drawing and roving processes by partitioning and the use of independent ventilation systems.

8. Serious attention should be given to more complete enclosure of opening, blending, picking and carding machines and design of a highly efficient exhaust system to remove fine dust.

9. At the present time, a successful occupational health program for the cotton textile industry should include efforts to remove or reduce dust prior to processing, efficient machine exhaust and ventilation systems, and medical surveillance to detect susceptible workers before they acquire permanent pulmonary impairment.

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EXHIBIT 6-55

Molyneux & Berry, "The Correlation of Cotton Dust Exposure With the Prevalence of Respiratory Symptoms"

* * * * *

FIGURE 4

CORRELATION. BYSSINOSIS IN FIVE OCCUPATIONS

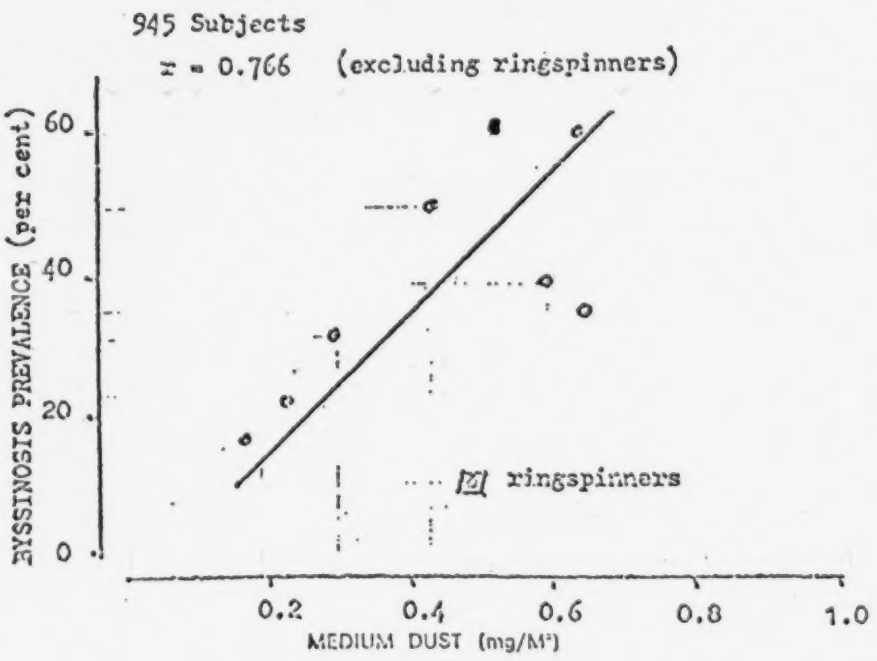

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FIGURE 5
CORRELATION. BYSSINOSIS IN SPEEDFRAME TENTERS

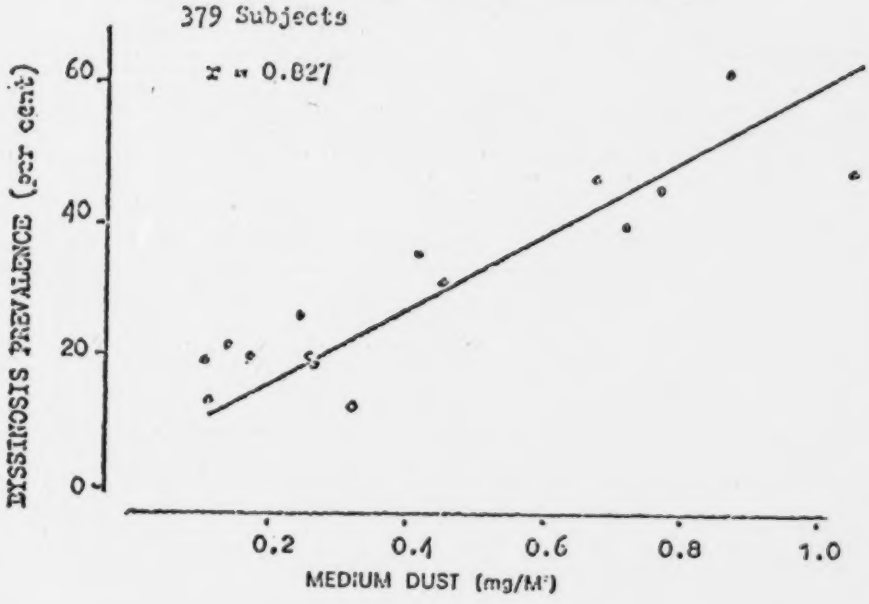

FIGURE 6
CORRELATION SIMPLE BRONCHITIS in non smokers (35-54 years)

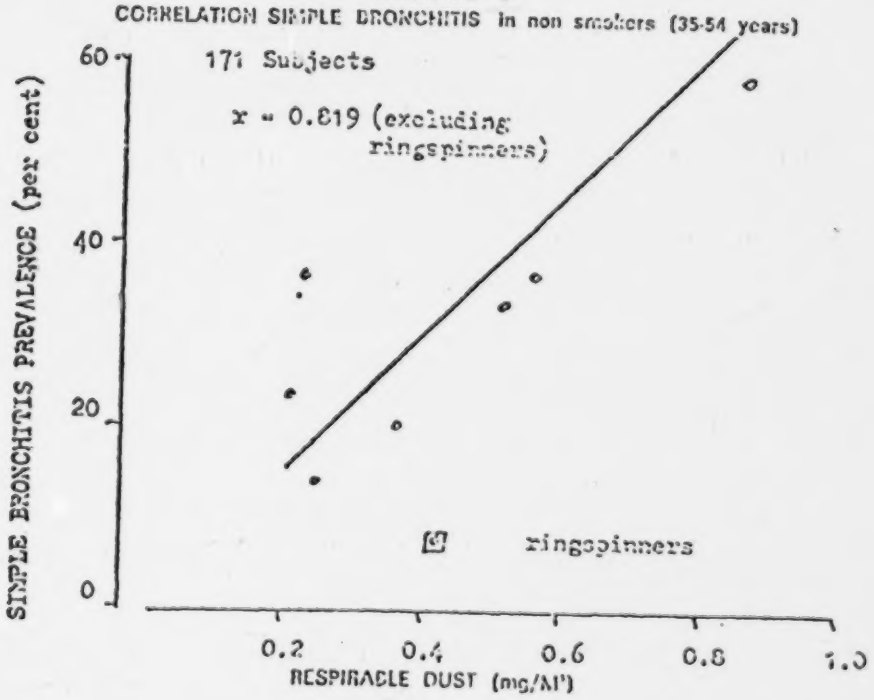

EXHIBIT 6-57

Experience with Medical Surveillance Programs

By: Harold R. Imbus, M. D., Sc.D.
Medical Director
Burlington Industries, Inc.

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Nevertheless, one can see the marked difference in the incidence of symptoms of tightness in the chest and in the decline of FEV_1 in these employees. Only one employee has Grade I byssinosis. This is now becoming a manageable situation in which medical surveillance can identify susceptible individuals, monitor their respiratory function periodically, advise regarding respirators, and smoking habits, and even consider transfer if necessary.

Table II illustrates the card room of another plant. In early 1971 an initial survey was done. Dust levels were high and Column 1 shows clearly that there is a significant problem and something needed to be done.

Clearly there was little more that a medical surveillance program could do than to identify the problem, which was too much dust. Control measures were instituted shortly thereafter with installation of new card cleaning equipment. You can see from Column 2 that dust levels were lowered by about two-thirds and so was the percentage with symptoms of byssinosis. Decrement in FEV_1 was also decreased significantly. However, further improvement here is highly desirable. Unfortunately, many tex-

tile plants find themselves in this position, having installed ventilation equipment, in the last few years, at large expense, which though what was generally available, is not adequate to control the byssinosis problem. At this time, an entirely new installation of chute feed carding is in process in this plant and dust levels will be much lower in the near future. Likewise, it is anticipated that the number of reactor employees will be much lower.

Table III, left side, illustrates a survey of a card room and drawing area in a rather large cotton blend plant which has spun cotton yarn for many years. Dust levels in both areas are approximately .4 milligram per cubic meter. In the card room, no employee has symptoms of byssinosis and only one (3%) had a decrement of 10% or more in FEV_1. It is seen that average FEV_1 actually increases during the working day. In the drawing area, 3.2% have byssinotic symptoms and 6.5% have a decrement of FEV_1 of 10%, an average decrement of 48cc, about what we have at our Corporate Headquarters. This plant uses a higher grade of cotton blend and it appears that we have an entirely manageable situation. With medical surveillance, any employee having problems can be detected early and protected either with a respirator or by transfer.

On the other hand, Table III, right side, shows a small area in another plant with dust levels somewhat comparable, but incidence of symptoms and decrement of FEV_1 is much greater. Other areas in this plant were found to have even higher dust levels, but I show these areas because dust levels are in the same "ball park." This is a 100% cotton plant. Even though dust levels here do not look inordinarily high, it is obvious that further action needs to be taken to lower them, and medical surveillance is strictly an interim measure.

* * * * *

The point I am trying to make by using these examples is that in order for a medical surveillance program to provide any real protection you must first of all have a manageable situation.

* * * * *

We believe that medical surveillance programs can provide protection for employees when combined with environmental control. They offer a valuable tool, in addition to dust measurement, for evaluation of the effect of that environment upon employees. They can identify the employee who has a problem and provide him with medical assistance and in receiving benefits that are due him. They can identify the employee who is an increased risk, inform him, and help him to take necessary measures to protect himself. Medical surveillance programs are not a substitute for diligent efforts to control dust.

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EXHIBIT 6-66

An Epidemiological Study of Respiratory Symptoms in Lancashire Mills, 1963-66

M.K.B. MOLYNEUX and J.B.L. TOMBLESON

Department of Occupational Health, University of Manchester and H.M. Medical Inspectorate of Factories

Molyneux, M.K.B., and Tombleson, J.B.L. (1970). *Brit. J. industr. Med.*, 27, 225-234. An epidemiological study of respiratory symptoms in Lancashire Mills, 1963-66. An epidemiological study of card and blowroom workers in 14 cotton spinning and two man-made fibre spinning mills in Lancashire had been carried out on a prospective basis of six-monthly examinations over three years. The number of operatives to be included was decided so as to give a sufficient sample for the statistical assessment of fall in FEV, at the same time allowing for population movement. The examination of each worker included a history, a questionnaire of respiratory symptoms, and a measurement of forced expiratory volume in one second. The results in this paper, which will be followed by others on other aspects of the survey, give the prevalence of both byssinosis and bronchitis, according to the definition given, in the 1,359 cotton workers and 227 man-made fibre workers, seen at least once, and also the dust levels in the mills. Eight of the mills processed coarse and six medium cotton.

The total prevalence of byssinosis, as defined in 26.9%, being higher in coarse than in medium cotton mills, and the occupational groups most affected are strippers and grinders, carders and undercarders, and draw frame tenters. In coarse mills symptoms develop in some men and women within the first four years of exposure, and in medium mills between five and ten years' exposure. Repeat questionnaires in about half the population, two

years after the first questionnaire, showed the development of symptoms of chest tightness in an appreciable number not previously affected. The incidence of bronchitis is increased in operatives with symptoms of byssinosis, but is influenced by age and smoking.

Total dust levels averaged 3.1 mg/m³ in coarse mills and 1.2 mg/m³ in medium mills. The findings indicate that dust control measures, though they have produced considerable improvement, are not now fully effective with present methods of production.

* * * * *

TABLE 3

BYSSINOSIS: PREVALENCE (%) IN POPULATION SEEN

Grade	*All cotton*			*Man-made fibre*		
	Male	*Female*	*Total*	*Male*	*Female*	*Total*
½	6.9	6.7	6.8	1.0	2.3	1.8
I	13.8	12.7	13.2	3.1	1.5	2.2
II	7.6	6.2	6.8	0.0	0.8	0.4
Total	28.3	25.6	26.7	4.1	4.6	4.4
No.	566	793	1359	97	130	227

TABLE 4

BYSSINOSIS: PREVALENCE (%) IN 10 OCCUPATIONS IN MEDIUM AND COARSE MILLS

Occupation	Mill	Prevalence (%)				Total No.	Mean exposure (yr)
		Grade ½	Grade I	Grade II	All grades		
Blowroom and cotton chamber (male)	Medium	6·0	12·0	6·0	24·0	50	9·7
	Coarse	6·4	4·3	3·2	13·8	94	11·8
Carder, undercarder (male)	Medium	5·3	23·7	7·9	36·8	38	19·1
	Coarse	14·5	14·5	10·9	40·0	55	19·2
Stripper and grinder (male)	Medium	9·2	22·4	17·1	48·7	76	18·5
	Coarse	9·9	34·1	14·3	58·2	91	17·0
Card tenter (female)	Medium	0·0	7·9	2·6	10·5	38	13·9
	Coarse	8·6	17·1	0·0	25·7	70	9·6
Drawframe tenter (female)	Medium	7·5	9·4	13·2	30·2	53	20·0
	Coarse	11·4	14·8	14·8	40·9	88	22·2
Speedframe tenter (female)	Medium	6·0	9·0	6·0	21·0	167	28·0
	Coarse	7·6	20·5	6·7	34·8	210	26·8
Comber tenter (female)	Medium	6·0	10·0	0·0	16·0	50	14·3
	Coarse	—	—	—	—	(0)	—
Ring spinner (female)	Medium	—	—	—	—	(0)	—
	Coarse	3·7	3·7	3·7	11·1	108	18·0
Labourer (male)	Medium	0·0	0·0	4·0	4·0	25	8·3
	Coarse	4·8	0·0	0·0	4·8	42	6·8
Wasteman (male)	Medium	—	—	—	—	(2)	—
	Coarse	15·4	0·0	7·7	23·1	13	14·5

EXHIBIT 6-73

Schilling, *et al.*, "Cardiovascular Disease in Cotton Workers"

* * * * *

Sources of Unreliability in Mortality Rates

Many doctors certify multiple causes of death from which the Registrar General must select one for computing death rates for specific diseases. The practitioners often cannot verify their diseases either by necropsy or special investigation. Thus both the Registrar General and the general practitioner introduce possible sources of error into the mortality rates ascribed to specific diseases. And as the habit of multiple certification has become more common in recent years, the secular trends in the mortality rates of certain diseases may therefore be seriously misleading.

Multiple Certification.—When the medical practitioner gives more than one cause of death on the certificate the Registrar General selects one according to certain rules. In 1921-23 and 1930-32 any definite diseases of the heart or kidneys was preferred to any disease of the respiratory system when both were mentioned together. In 1939 the Registrar General's selection rules were revised. Preference is now given to the disease which, as far as can be ascertained was, in the opinion of the certifying medical practitioner, the starting point of the sequence leading up to the immediate cause of death. The effect of adjusting bronchitis and cardiovascular death rates for 1921-23 and 1930-32 in the light of this revision cannot be shown accurately, but it is possible to get some idea of the likely change from two different sources—the Registrar General's statistics for 1939 (the year of change), when he classified all the death certificates according to both new and old rules, and from a review of the death certificates of card room workers, applied by the trade unions. The latter is a source of information often available but seldom used.

The relevant conclusion of the Registrar General (1947) as regards our particular problem is:

> "Bronchitis and asthma death rates have been affected considerably . . . by the increasing mention of myocardial degeneration as a contributory cause of death and consequent classification by the (old) rules of selection, of increasing numbers to heart disease."

He gives conversion factors so that an estimate may be made of the number of deaths before 1939 from diseases, of the myocardium among the general population which would be put back to respiratory deaths if the new selection rules applied. For bronchitis in *all* males there is added 0.237 times the number of deaths which were previously ascribed to diseases of the myocardium. But for groups with a high respiratory mortality a higher proportionate transfer should be made. There is, however, another method available for the very necessary interpretation of the Registrar General's rates of cardiovascular and respiratory mortality before 1939. But it must be emphasized that it is a highly tentative procedure. In 1939, when deaths were given classified under both rules, the bronchitis deaths under the new classification were increased by transference from disease of the myocardium, endocarditis, and arteriosclerosis from amounts varying from 30% at ages 25-34 to 114% at ages 65-69. If these age-specific conversion factors are applied at the appropriate ages, the death rates from cardiovascular causes in 1930-32 are reduced by the following amounts for ages 25-69 (Tables C and E).

Weavers	8%
Spinners	10%
Strippers and grinders	24%
All males	10%

We have assumed that practitioners combined bronchitis and heart diseases on their death certificates in much the same proportions in 1930-32 as in 1939 and that the practice was similar among practitioners in cotton areas as elsewhere.* We have no means of verifying these two proportions, but if our assumptions are reasonable, cardiovascular death rates for strippers and grinders would be reduced under the new system of classification by more than twice as much as the similar rates for all males and the other cotton groups.

Death certificates of 256 card and blow room workers, or known ex-card and blow room workers, of all ages in the Rochdale, Oldham, and Bury areas, obtained from the trade unions, were examined. These covered a period from 1941 to 1948. In Fig. 4 the effect of the change in methods of classification is shown for the 25-69 age group in which there were 164 deaths.

Of the 24 additional deaths from respiratory causes under the new system of classification, 19 were transferred from diseases of the myocardium, three from endocarditis, one from "other heart diseases", the remaining one coming from chronic rheumatism. This transference lowers the cardiovascular death rate for ages 25-69 by

$$\frac{23}{67} \times 100 = 34\% \text{ **}$$

This compares with the 24% estimated by the other method.†

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* As multiple certification continued to increase between 1930 and 1940 we may have overestimated the reduction.

** In addition to transferring 23 deaths from cardiovascular to respiratory causes, two other deaths were transferred to the cardiovascular group from other causes, giving a net loss of 21 deaths as shown in Fig. 4.

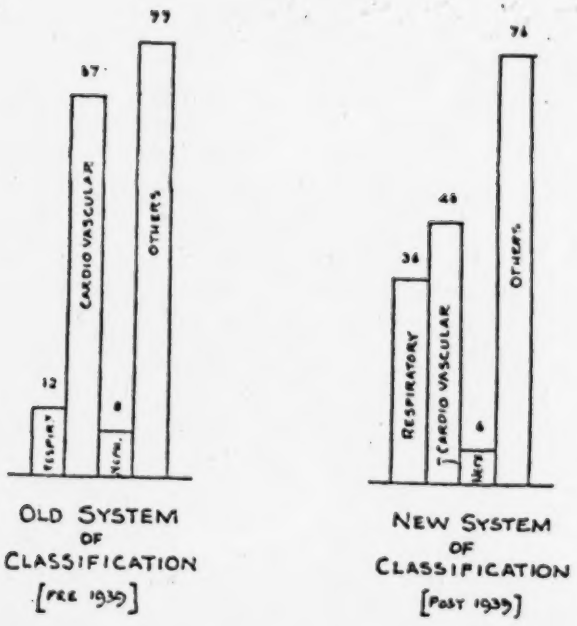
† For all ages, the transference lowered the cardiovascular death rate by 30%.

FIGURE 4

CLASSIFICATION OF CAUSE OF DEATH
OF 164 CARD AND BLOW ROOM WORKERS

1941 - 1948

AGES 25 - 69



The Registrar General (1949) records that in the 1921-30 decennium 33% of all death certificates for non-violent deaths gave "multiple" causes. By 1935 this proportion in all death certificates had risen to 43%. It is reasonable to infer that there was a substantial increase in multiple certification between 1921-23 and 1930-32, which would mean that a higher proportion of respiratory deaths would be allocated to cardiovascular deaths in the latter than in the former triennium. This may be a possible explanation of the opposite secular

trends in cardiovascular and respiratory mortality, and in fact both these death rates may have been falling.

The North IV (Lancashire and Cheshire) region in 1930-32 showed a mortality excess from respiratory diseases over all males at all ages. Some of the cardiovascular mortality excess for this region can be similarly explained. But, even after reclassification by the methods given above, death rates for heart diseases and nephritis for males in North IV are still significantly greater than rates for all males at ages 45 and over, but spinners and strippers and grinders have higher rates than North IV at ages over 55 (Table D). These high cardiovascular death rates for North IV cannot be explained.‡

Errors in Diagnosis.—It is not possible to be certain about the effects on mortality rates of using vague terms to describe causes of death, or of frank errors in diagnosis. The cardiovascular group of diseases includes myocardial diseases and degeneration which are vague labels used for diseases in which the exact pathology is not known. The use of "heart failure" as a cause of death is not favoured by the Registrar General, and for these diseases of uncertain pathology in which cardiac failure is the terminal result, the general practitioner undoubtedly uses "myocarditis" and the like in order to avoid enquiries about his certificates.

We have considered the reallocation to respiratory deaths of certificates on which both cardiovascular and respiratory causes are mentioned; but it is probable that there are some death certificates with no mention of respiratory disease, even though such a disease was the starting point of the pathological changes leading to death. And it is also probable that such an event occurs even

‡ It is of interest that in 1947-8 a similar excess for heart disease is still present, in spite of the new methods of classification.

more often among cotton workers exposed to dust than among all males or men of the same social class, for reasons which will now be discussed.

Byssinosis has been repeatedly described as a disease which closely simulates chronic bronchitis and emphysema, but O'Sullivan found that among 33 men suffering from disabling byssinosis 12 had no clinical evidence of bronchitis. Shaw Dunn, and Sheehan (1932) did necropsies on 10 cotton mill workers, nine of whom had been exposed to dust; while all of these nine had some evidence of chronic bronchitis and emphysema, six showed hypertrophy of the right ventricle, four of whom died of congestive cardiac failure. Thus cotton workers with disabling byssinoisis, with its characteristic asthmatic symptoms, may present a clinical picture of cardiac asthma or congestive cardiac failure, which so masks the respiratory disease that it is not mentioned on the death certificate.

For nephritis it is possible to make more definite assumptions about mistakes in diagnosis.

Platt (1947a) suggests that most of the deaths assigned by the Registrar General to nephritis in the older age groups are not renal deaths at all. In his own 161 cases for which full records were available, the main incidence of deaths from nephritis was under the age of 45. The Registrar General's figures for age incidence are totally different, with the main mortality over the age of 45. Platt's own experience is that many cases of hypertensive cardiac failure with albuminuria are diagnosed by their general practitioners as chronic interstitial nephritis.

Nephritis death rates are particularly high in certain occupations. Greenwood and Russell (1938) showed that in the 1921-23 triennium the textile trades, pottery dippers and file cutters, all of whom had high nephritis death

rates also had a high risk of dying from respiratory disease.

For all occupations there is a significant correlation between the standardized death rates for bronchitis and nephritis in 1921-23 (Table 2). In 1930-32 the same type of occupations appear to have high nephritis death rates—blow room workers and foremen, strippers and grinders, and cutlers—but for this period, as shown in Table 2, there is a significant correlation between the standard mortality ratios of bronchitis and nephritis only for Social Classes III and IV. A possible explanation for this relationship is that many of the men in these trades died of congestive cardiac failure caused by respiratory disease and were certified as nephritis deaths.*

Thus there is some evidence that medical practitioners may fail to distinguish renal disease from other diseases which in their terminal stages simulate renal disease. It seems possible, therefore, that the mortality excess from nephritis in cotton workers may be due to deaths from respiratory disease, which terminates as congestive cardiac failure. If, however, occupational influences cause hypertension, as has been suggested, there will be another reason for high "nephritis" death rates in cotton workers.

Conclusions

In order to get a clearer picture of any occupational mortality excess due either to cardiovascular and respira-

* In the same paper Greenwood and Russell drew attention to the high nephritis death rates in barmen and inn and hotel keepers for whom an excess of alcohol is probable. In the triennia 1921-23 and 1930-32 there is a significant correlation between standardized death rates for nephritis and cirrhosis of the liver. It is possible that this correlation is due to some cases of cirrhosis of the liver which terminally have oedema being misdiagnosed as nephritis. Fishberg (1939) quoting his own experience and that of others is very sceptical of the role of alcohol in producing renal disease.

tory diseases for the triennium 1930-32, cardiovascular and respiratory deaths are given in Fig. 5, added together, for the cotton trades, for all males, and for males of similar social classes to the cotton workers. The occupational hazard of the cotton trades, particularly of the stripper and grinder, is obvious. We know that most of this is respiratory and that in the past respiratory mortality of cotton workers has almost certainly been underestimated; but when a correction is attempted for the respiratory deaths allocated to the cardiovascular group of diseases, there still seems to be an excess of deaths for the cotton workers and particularly so for the strippers and grinders. Thus there may be a real excess of heart disease due to occupational influences. The latter possibility is so important in view of the very high national death rate from cardiovascular diseases and the absence of information on its relation to environmental factors that this clue must be followed up. As Morris (1951) said, cardiovascular disease of middle and old age is one of the darkest areas of vital statistics and at present the main source of information must be the mortality rates. In another paper the results of a clinical investigation of more than 300 men employed in cotton textile mills will be described.

TABLE 2

CORRELATION BETWEEN NEPHRITIS AND BRONCHITIS (AGES 20-64 YEARS)

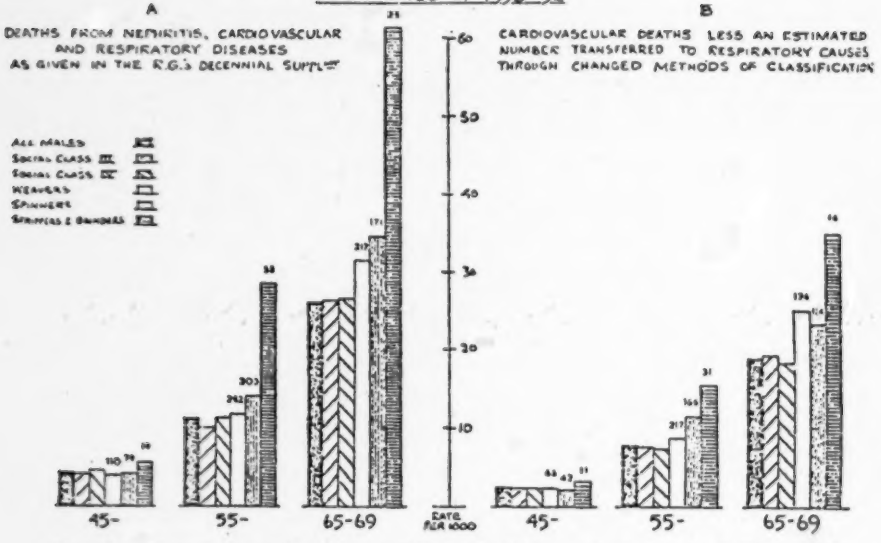
Nephritis and Bronchitis	r	No. of Groups	P
1921-23*	$.38 \pm .04$	164	$P < .001$
1930-32†	$.22 \pm .12$	71	Not significant
1930-32 (Social Class III-V)	$.44 \pm .13$	59	$P < .01$

* From Registrar General's Decennial Supplement, based on C.M.F.'s of all trades and referring to chronic nephritis only.

† Based on S.M.R.'s of trades with 10 or more deaths, and referring to acute and chronic nephritis.

FIGURE 5

DEATH RATES IN 1930-32



Figures above columns for cotton workers are number of deaths upon which rates are based. (See Appendix, Tables C and E.)

Summary

Since 1891 the Registrar General has recorded high death rates from cardiovascular diseases among cotton workers.

It has been suggested that this mortality excess may be due to hyperpiesis caused either by the inhalation of textile dusts or by inbreeding in Lancashire cotton towns.

In this paper the Registrar General's figures are analysed principally for the triennium 1930-32 (the last to be published). It is shown that in the three occupational groups studied, strippers and grinders, weavers and spinners, there is an association between mortality and the extent of dust exposure.

The significantly high death rate of the strippers and grinders (the occupation with the highest dust exposure) from cerebral vascular lesions supports the hypothesis

that hyperpiesis may be the cause of this mortality excess.

Two sources of unreliability in mortality rates are discussed. (1) Since 1920 medical practitioners have entered multiple causes of death with increasing frequency on death certificates. The Registrar General makes rules for selecting one cause of death from certificates with multiple causes. Before 1939 these rules exaggerated cardiovascular mortality and reduced respiratory mortality. Since 1939 more reliable methods of selection have been used, and some of the cardiovascular mortality of cotton workers who it is known have high respiratory death rates from byssinosis can be explained simply by methods of book-keeping. (2) The use of convenient though vague terms such as "myocarditis" to describe causes of death, and errors in diagnosis, particularly of nephritis in the older age groups, may also exaggerate cardiovascular death rates.

When all possible corrections are made for the exaggeration of cardiovascular mortality through the erroneous allocation of respiratory deaths to it, there still remains an excess of cardiovascular mortality particularly for strippers and grinders. This may well be real and may be due to occupational influences.

We should like to thank Dr. J. N. Morris of the Social Medicine Research Unit of the Medical Research Council, Dr. W. P. D. Logan of the General Register Office, Mr. G. Hart of Rugby Mill, Hollinwood, and our colleagues inside and outside our Department for advice and criticism; Mr. A. Robertson, Mr. H. Chorlton and Mr. J. Meadowcroft of the Card and Blowing Room Operatives and Ring Spinners Association.

EXHIBIT 6-76

Research Triangle Institute, Technological Feasibility Assessment and Final Inflationary Impact Statement

Table I-6. Total Installed and Annualized Compliance Costs: all Sectors (Costs in Millions of Dollars)

Industry Sector	Exposure Limit (mg/m^3)	Installed Cost	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
Yarn Production	0.5	211.8	33.8	6.9	20.6	61.5
	0.2	984.4	158.3	15.6	67.9	241.6
	0.1	2,802.7	450.6	23.3	147.0	620.6
Cotton Ginning	0.5	16.9	2.7	4.9	1.8	9.4
	0.2	292.2	47.0	13.2	30.3	90.4
	0.1	343.6	55.2	14.7	35.4	105.3
Cotton Weaving	0.5	9.1	1.5	1.7	0.6	3.7
	0.2	1,387.9	223.1	40.7	86.3	350.1
	0.1	3,939.1	633.2	112.6	245.1	990.9
Waste Processing	0.5	17.3	2.8	2.6	2.5	7.9
	0.2	32.0	5.2	2.9	4.7	12.8
	0.1	56.1	9.0	3.4	8.2	20.6
Total	0.5	255.1	40.8	16.1	25.5	82.5
	0.2	2,696.5	433.6	72.4	189.2	694.9
	0.1	7,141.5	1,148.0	154.0	435.7	1,737.4

* * * * *

III. BENEFITS OF THE PROPOSED STANDARD

1. *Introduction*

This chapter identifies occupational groups exposed to cotton dust, discusses the inherent problems of benefit estimation, and estimates the benefits expected to result from implementation of the proposed standards. Yarn preparation workers and other cotton industry workers are discussed separately herein.

2. *Occupational Groups Exposed to Cotton Dust*

Two large groups of workers known to be exposed to cotton dust are considered in this evaluation. They are:

1) yarn preparation workers, and 2) workers engaged in weaving, ginning, cottonseed oil milling, and industries using cotton waste.

a. *Yarn Preparation Workers*

In August 1971, 338,310 production workers were employed in cotton and man-made fiber mills * in the United States according to a Bureau of Labor Statistics (BLS) survey [1]. Cotton mills employed 193,014 production workers, while man-made fiber mills employed 145,296 such workers. Of the total production workers, an estimated 22,609 were employed in bleaching, cloth dyeing and finishing, and fabricating departments; hence, they were not considered part of the regular textile operations work force. The regular textile operations work force then becomes, by subtraction, 315,701.

At the time of the BLS survey, slightly less than one-half of the industry's production workers were employed in mills manufacturing all or most of their products entirely of cotton fibers and approximately one-fifth were in mills manufacturing products of cotton and man-made fibers (blends). The balance of the production workers (thirty percent of the production work force) were employed in mills manufacturing all or most of their products entirely of man-made fiber.

The BLS survey estimated the number of workers in cotton mills and all textile mills by selected production occupations. The estimates for cotton mill yarn preparation workers were excerpted without change from the BLS report and are shown in Table III-1. The numbers of yarn preparation workers in blend plants, also shown in Table III-1, were obtained by multiplying the BLS estimates for all textile mills by 0.2 (the fraction of

* Includes SIC 2211, Weaving Mills, Cotton; SIC 2221, Weaving Mills, Manmade Fiber and Silk; SIC 2281, Yarn Mills, Except Wool; SIC 2282, Throwing and Winding Mills; and SIC 2284, Thread Mills.

workers in mills manufacturing products of cotton and man-made fibers). Maintenance and miscellaneous worker estimates for both cotton and blend mills were prorated from figures for all textile production employees. The median dust concentrations assigned to the several production occupations listed in Table III-1 are from Merchant, et al. [2], and are measured dust levels from six cotton mills and eleven blend mills. The dust samples were of approximately six hours duration and were collected with the Lumsden-Lynch vertical elutriator.

Inspection of Table III-1 reveals that 105,193 and 21,230 yarn preparation workers are exposed to cotton dust in cotton and blend mills, respectively, and are at risk of developing byssinosis.*

* * * * *

A commonly used measure of the benefit of health programs is the value of future earnings lost due to premature death. Since byssinosis rarely appears as a cause of death on a death certificate, and further, since the relationships are not well defined between cotton dust exposure, byssinosis, and chronic bronchitis-emphysema deaths which are more commonly recorded, lost earnings due to premature death could not be calculated. While excess mortality ** due to bronchitis and pneumonia has been observed in English workers exposed to cotton dust [8], it has not been seen in the limited number of studies of mortality in the U.S. textile industry. Thus, Enterline and Kendrick [9] studied 6,281 white male cotton textile workers aged 15 to 64 as a control population in an examination of mortality in asbestos workers. Using the U.S. white male population as the standard, a Standardized Mortality Ratio (SMR) ([Observed deaths/Expected

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* Office and yarn dyeing workers are not included.

** More deaths than would be expected in a given population during a given period.

Table III-1. Estimated Number of Yarn Preparation Workers Exposed and Degree of Exposure to Cotton Dust by Job Classification (SIC's 2211, 2221, 2281, 2282, and 2284)

DEPARTMENT AND JOB CLASSIFICATION	COTTON MILLS		BLEND MILLS[a]	
	Number of Workers	Median Dust Concentration (mg/m^3)[b]	Number of Workers	Median Dust Concentration (mg/m^3)[bc]
Opening and picking				
Opener tenders	771	1.50-1.59	247	0.30-0.39
Picker tenders	1,293	1.60-1.69	324	0.50-0.59
Subtotal	2,064		571	
Carding and drawing				
Card grinders	1,273	1.70 - 1.79	333	0.60 - 0.69
Card strippers	123	1.70 - 1.79	32	0.60 - 0.69
Card tenders (finishers)	3,572	1.70 - 1.79	108	0.60 - 0.69
Comber tenders	658	0.70 - 0.79	168	0.30 - 0.39
Drawing-frame tenders	2,804	0.70 - 0.79	903	0.30 - 0.39
Slubber tenders, standard	575	0.40 - 0.49	159	0.10 - 0.19
Slubber tenders, long draft	3,698	0.40 - 0.49	1,034	0.10 - 0.19
Subtotal	12,703		2,737	
Spinning				
Doffers, spinning frame	18,894		2,500	
Section men (fixers)	2,837		824	
Spinners, ring frame	29,012		4,375	
Spinners, frame, other than ring	- - -		12	
Subtotal	50,743	0.20 - 0.29	7,711	0.00 - 0.09
Spooling, winding, and twisting				
Twister tenders, ringframe	1,921		1,308	
Uptwisters (manmade fiber)	- - -		450	
Winders, yarn	30,788		6,315	
Subtotal	32,709	0.20 - 0.29	8,073	0.10 - 0.19
Maintenance and miscellaneous	6,974	0.485	2,138	0.163
TOTAL	105,193		21,230	

[a] Processing 50 percent cotton or less.

[b] Six-hour vertical elutriator samples.

[c] Mixture of cotton dust and other dust present.

Data source: U.S. Department of Labor, Industry Wage Survey, Textiles, August 1971, Part 1. Cotton and Manmade Fiber, Bulletin 1801., Washington, D.C.: U.S. Government Printing Office, 1974.

J.A. Merchant, et. al., "Dose Response Studies in Cotton Textile Workers". J. Occup. Med., Vol. 15, No. 3 (March 1973) pp. 220-230.

Table III-2. Other Workers Exposed to Cotton Dust and Assumed Exposures

SIC	Title	Number of Workers[a]	Assumed Exposure: Operation	Dust Concentration (mg/m^3)	Method	Country	Reference
0724	Cotton ginning	40,446[b]	gin stand	1.02 (median)	vertical elutriator	U.S.A.	3
			baling press	0.48 do	do	do	
			other	0.59 do	do	do	
			overall	0.67 do	do	do	
2074	Cottonseed oil mills	900[c]	seed house	23-590 total dust	filter thimble	Egypt	4
			linter	15-18 do	Greenburg-Smith impinger	Australia	5
			baler	30-37 do	do		
2211	Weaving mills, cotton	83,216[d]	slashing and warping	1.0-1.09 (median)	vertical elutriator	U.S.A.	2
			weave room	1.0-1.09 do	do	do	
			cloth room	1.0-1.09 do	do	do	
			maintenance	1.0-1.09 do	do	do	
2221	Weaving mills, manmade fiber and silk		slashing and warping	1.0-1.09 do	do	do	2
			weave room	0.59 do	do	do	
			cloth room	0.59 do	do	do	
			maintenance	0.59 do	do	do	
2241	Narrow fabric mills	23,500	weave room, blend mill	0.59 do	vertical elutriator	U.S.A.	2
			weave room, cotton mill	1.0-1.09 do	do	do	
2293	Paddings and upholstery fillings	3,500	garnett room	6.06 (mean)	do	do	6
2294	Processed textile waste	3,100	sorting	0.53 (respirable dust)	horizontal elutriator	Egypt	7
			fiber loosening	6.84 do	do	do	
			carding	5.02 do	do	do	
			spinning	1.12 do	do	do	
			felt processing	3.20 do	do	do	
2296	Tire cord and fabric	7,214[e]	weave room	0.59-1.09 (median)	vertical elutriator	U.S.A.	2
2515	Mattresses and bedsprings	23,200	garnett room	6.06 (mean)	do	U.S.A.	6
			tape edge	0.36 do	do	do	
			quilting	0.28 do	do	do	
			box spring	0.43 do	do	do	
			hand tie and coil tack	0.24 do	do	do	
			overall	5.02 do	do	do	

a Obtained from 1972 Census of Manufactures unless noted otherwise.

b If a gin crew is 12.5 workers (National Cotton Council), then in 1972 there would have been 12.5 workers/gin X 3,517 active gins = 43,963 workers. However, 8 percent (3,517) of these are assumed to be office workers. Hence, the workers exposed to cotton dust is estimated as 40,446.

c Twenty percent of production employees (4,500) is assumed based on conversations with industrial representative.

d Adapted from detailed data reported to U.S. Department of Labor, Industry Wage Survey, Textiles, August 1971, Part 1 Cotton and Manmade Fiber, Bulletin 1801. Washington, D.C.: U.S. Government Printing Office, 1974.

e Estimated.

deaths] X 100) of 59.4 was calculated for respiratory disease, indicating that respiratory disease mortality in white male cotton textile workers is less than that of the U.S. white male population. This finding was confirmed and extended in a recent analysis [10]. The results of a study of mortality in female cotton textile workers reported by Daum, et. al. [11] are suggestive of increased emphysema deaths. Given the large number of female workers in the cotton textile industry (about 55 percent of the work force), it is especially unfortunate that hard mortality data are not available. SMR's for chronic bronchitis and emphysema in both male and female cotton textile workers would be especially appropriate for use in this analysis; unfortunately they are not available at this time.

* * * * *

4. *Engineering Controls*

Engineering controls are defined herein as substitution of a less toxic substance for a more toxic one, modification or isolation of a process, or local or general exhaust ventilation for the purpose of reducing or eliminating a worker's exposure to a potentially harmful substance. Thus, dust concentrations in the textile industry may be controlled by modification of the dust-producing processes or operations, or removal of the dust from the environment by ventilation.

a. *Yarn Production*

1) *Process Modification*

The yarn production process is essentially one of fiber cleaning and alignment with the desired goal of removing all material in the cotton except mature fibers, which are then spun into yarn. The dust associated with cotton processing is thus an unwanted residue which is inherent in the operation. Textile processes have changed

little over the past several decades although there have been modifications of some operations, primarily to increase productivity; hence, process modification, other than improved maintenance, has had little effect on dust concentrations. The design of high speed cards did require substantially improved dust capture to avoid production problems arising from the larger volume and greater agitation of materials being processed. On the other hand, open end spinning, which eliminates roving, may produce more dust than ring spinning.

Decreasing machine density in a work area, which is mentioned in the literature as a means of reducing exposure, does not, in fact, reduce the concentration of dust in the room air. Area dust levels would build up more slowly in the larger volume of room air, but would eventually reach the same equilibrium levels if other controls were unchanged. This technique is, therefore, felt to offer little to the solution of the problem of dust control in the textile industry. Replacement of older, low-speed production equipment with more modern, high-speed machines can reduce the generation of dust. However, very fine yarns cannot be produced by the higher speed equipment, so replacement is not a universal solution. Only in instances where large amounts of lower quality yarn are desirable would replacement be applicable. Presently, process modification appears to be a feasible but limited alternative for dust control [2].

2) *Ventilation*

The capture and removal of dust from the air at the point of generation (i.e., local exhaust ventilation) appears to be the most efficient method of dust control at the present time. Effective dust removal in cotton processing areas depends on two factors: capture devices located as close as possible to the point of dust generation and efficient filtration methods [2]. Considering only the technological feasibility of efficient capture devices and filters,

the scope of ventilation control at the dust source could range from complete enclosure of each machine (including total enclosure, ducting, and filtration) to application of local exhaust ventilation hoods and ducts and adequate collection devices.

Most older textile equipment has very few enclosed dust generating points. When local exhaust ventilation systems are included, they are usually retrofitted devices. The efficiency of these devices can be improved significantly by providing as much enclosure of the machine as practicable. By confining the contaminant to a smaller volume, air flow requirements, and hence, energy costs are reduced. Since the air volume required for the majority of the dust capture devices is directly proportional to the capture distance, a reduction of one-half of the capture distance results in a corresponding decrease of one-half of the air volume required, and hence, corresponding reductions in energy requirements. Many of the more modern machines are well enclosed and are equipped with dust capture devices as a standard feature.

There is little variation in the physical configuration of the capture devices required to attain the levels of control ranging from 1.0 to 0.2 mg/m^3. Vendors of exhaust ventilation systems currently prefer to add dust capture pickups, filtration devices, and/or increase airflows to reach desired room concentrations.

The level of dust control effected is generally related to the number and design of local exhaust hoods, air volumes, and the number of filter stages through which the contaminated air passes. By employing a sufficient number of well-designed dust capture devices (e.g., hoods, slots, and plenums), sufficient air volumes, and efficient single-stage filtration, dust levels in the range of 1.0 mg/m^3 (total dust) can generally be expected in the working environment; with two-stage filtration (and air washing), levels not exceeding 0.5 mg/m^3 (V.E.) may be

expected; if efficient third-stage filtration is added (and air washing), workroom dust concentrations should not exceed 0.2 mg/m³ (V.E.) for an eight hour time-weighted average (TWA) for yarn-producing mills. Controls to comply with a 0.1 mg/m³ (V.E.) level of control are currently technologically feasible, but may require complete equipment enclosure and stringent three-stage filtering of both recirculated and make-up air in the ventilation system since dust in the ambient make-up air may on occasion exceed 0.1 mg/m³ (V.E.).

Control of cotton dust concentrations in the yarn manufacturing industry to levels as low as 0.1 mg/m³ (V.E.) thus appears to be technologically feasible by application of existing technology. This assessment is based on RTI's understanding of the processes and operations involved, the amount and velocity of particle release from various dust generation points, and the general capabilities of current engineering controls. It appears that control of dust levels to meet the 0.1 mg/m³ exposure limit will require: (a) complete enclosure of openers and pickers, cards, draw frames, combs, roving frames and spinning frames with air exhaust; (b) filtration of the exhaust air from the enclosures to levels approximating 0.1 mg/m³; (c) recirculation of the filtered exhaust air through the central air conditioning system, where additional cleaning takes place; and (d) filtration of air conditioning make-up air to a level not exceeding 0.1 mg/m³. Such a system is conceptually feasible although no empirical verification can be provided since it apparently has not been tried in any installation. The configuration of the enclosures may be expected to provide the greatest design problems, since it will be necessary to provide numerous access ports and a means to check for operating malfunctions either by direct inspection or by automatic indicators.

* * * * *

2) *Yarn Processing*

Yarn processing is a term used to cover those operations through which yarn may pass after leaving the spinning frame. These include winding, spooling, twisting, warping, and weaving, all of which are described in Appendix A.

Engineering controls are available for four of the five processes cited above; the exception is weaving. Based on information obtained from vendors, local exhaust ventilation systems could be used to maintain median dust concentrations of 0.5 and 0.2 mg/m^3 in areas housing these processes. RTI estimates that the 0.1 mg/m^3 limit could be achieved by adding filtration of the make-up air for the air conditioning system to the local exhaust ventilation systems.

Commercially available engineering controls applicable to weaving processes were not identified and it is, therefore, assumed that none exist. Some experimental work has been done with the concept of using general room ventilation as a dust control measure in weave rooms. This basically consists of modifying existing ventilation systems to produce air currents of such speed and direction as to capture a portion of the dust emitted from the weaving process and then filtering the dust from the air. No information on cost or effectiveness of this control technique is available.

Although the residue of particles of bract, stem, and leaf (the material suspected of being the causal agent in byssinosis) in weaving yarns is relatively very small, there is substantial evidence that enough exists in the dust found in weave rooms to pose a significant hazard for workers exposed over long periods. The bulk of weave room dust, however, apparently is sizing used to treat the yarn and the total airborne dust normally will exceed the 0.1, 0.2, and 0.5 mg/m^3 exposure limits considered

in this analysis, although cotton dust may be only a small portion of the total.

No documentation of engineering controls for looms was found in the course of this study. The discussion that follows is, therefore, entirely speculative. Three kinds of engineering controls may be suggested. Perhaps the simplest and most obvious is to isolate the weave room from other dusty areas. It was observed that in integrated mills the doors connecting the weave room with yarn production areas may stand open during production, with substantial dust drifting into the weave room. Elimination of such a dust source is easy and poses no cost penalty. Similarly, room ventilation systems should be separated so that dust is not introduced through recirculation from dusty areas.

The room ventilation system may be the primary means of lowering dust concentrations in the weave room. A very high air flow through the room, combined with high efficiency filtration, would appear to be appropriate. The use of floor vents drawing air at high rates from under looms may also be used. Another engineering control technologically feasible for control of most looms apparently is local exhaust ventilation. It is probable that hoods can be installed above most looms and that quite high rates of air flow can be employed to capture dust released from the loom or blown off by travelling cleaners where they are employed. Without knowing the range of possible specifications for air flows or distances from hood to dust source (which would require specific preliminary design analysis), it is not possible to estimate the collection efficiencies that can be attained with local exhaust ventilation. Air filtration is less difficult to conceptualize, since high efficiency can be achieved with multi-stage filter systems.

Good housekeeping procedures provide one other obvious control measure that can contribute significantly to

maintenance of low dust levels in the weave rooms. Careful and thorough cleaning of the room weekly to remove accumulated dust from equipment and from the room in general tends to prevent the build-up of excessive dust levels. This should be done at a time when production is shut down.

The aggregate effect of a combined control program such as discussed here is hard to estimate. RTI engineers are of the opinion, however, that such a program may reasonably be expected to achieve an exposure limit of 0.2 mg/m^3 TWA. It is not clear whether a limit of 0.1 mg/m^3 can be attained in this way.

* * * * *

b. *Reduction of Workers Exposure: Yarn Production Mills*

A wide range of engineering controls are technologically feasible to control dust levels in yarn mills. The industry naturally has chosen methods that are most cost effective. The controls specified herein as most probable for compliance with the proposed standards are those now in use, modified to achieve the required efficiencies. Their feasibility has been demonstrated and they are readily available from vendors. These controls reduce the dust concentration in the work area by capturing and removing the dust as it is generated through the use of local exhaust ventilation on production equipment. A typical system consists of dust capture devices (such as hoods or enclosures over dust emission sources), ducts for transporting the contaminant, and a filtration system for eliminating the dust from the airstream. These systems are discussed in Chapter IV and Appendix A.

Basically, the physical configuration of local exhaust ventilation systems is independent of the dust concentration considered. However, differences do arise in the additional stages of filtration required to control at the lower dust concentrations and in the dust capture devices and air volumes. The plant areas in which the systems

are employed also affect the control strategy required to comply with different levels of control. To achieve dust concentrations not exceeding 1.0 mg/m^3, it is assumed that local exhaust ventilation systems are now employed on opening, picking, carding and drawing operations and that a single stage of filtration is used. To achieve dust concentrations not exceeding 0.5 mg/m^3 (V.E.), RTI's analysis indicates that, in addition to the above operations, local exhaust ventilation will also be applied to combing, roving, and spinning operations and that two stages of filtration will be employed. To achieve dust concentrations not exceeding 0.2 mg/m^3 (V.E.), these data indicate that ventilation systems will be applied to the same operations with a third stage of filtration added, consisting of either an electrostatic precipitator or a high efficiency bag filter. Control to the 0.1 mg/m^3 limit requires enclosure of equipment, exhaust to high efficiency filters, and filtering of air conditioner make-up air.

In addition to engineering controls, a program to reduce worker exposure through improved specific work practices designed for each work position will be instituted. Although no specific modifications in work practices are suggested, for costing purposes it was assumed that a study of the work practices for a total of 21 work positions will be instituted by firms in the industry to identify possible improvements and workers will be given appropriate training based on the findings of the study. The type of work practice changes that may be instituted are discussed in Chapter IV.

During cleaning operations and certain other operations, such as waste collection and bale opening, which require manual handling of cotton fiber, the described ventilation controls are not adequate to maintain the exposure of the individuals involved in these operations at acceptable levels (see Chapter IV). Therefore, the probable methods of compliance include the use of per-

sonal protective devices for these individuals. Specifically, it is assumed that respirators are used by all individuals involved in blow down, stripping, grinding, dry sweeping, and manual trash collection. It is also assumed that disposable respirators are the most probable choice of the industry.

* * * * *

4. *Compliance Costs*

Costs associated with the implementation of controls to attain proposed cotton dust standards fall into two general categories:

- costs associated with the installation/operation of engineering controls
- costs associated with ancillary programs, e.g. medical surveillance, environmental monitoring, respirators, recordkeeping, and training.

All of the cost estimates shown are calculated as the incremental costs required for compliance with the proposed cotton dust standards, at alternative dust exposure levels. It is assumed that the existing regulation limiting worker exposure to dust concentrations not in excess of 1.0 mg/m^3 (TWA) applies to yarn production and processing industries and that for these industries there is no incremental capital cost for engineering controls to comply with an exposure level of 1.0 mg/m^3 (TWA).

At the time this study was performed it was evident that not all firms were, in fact, in compliance with the existing regulation, although the actual level of controls operating in the cotton yarn industry could not be determined. In order to provide a reference point for the incremental costs presented in this report, the costs of going from zero dust control to compliance with the existing 1.0 mg/m^3 exposure standard was estimated at $143.3 million, in 1974 dollars. Other costs associated with additional requirements of the 1.0 mg/m^3 standard scenario, such as medical, posting, personal protective

equipment, employee information, work practices, and monitoring and recordkeeping are addressed and are shown in the appropriate sections.

There is some ambiguity regarding the application of the existing regulation to the other industries for which costs are shown. It is Department of Labor policy that no regulation will apply to an agricultural operation unless it is so stated explicitly in the regulations. Since cotton gins are not explicitly covered by the existing regulations, it is assumed that industry is not covered. It appears that the cotton waste processing industries and the cottonseed oil industry have not been required to comply with the existing regulations although it might be construed technically to apply to them. For this analysis, they were not assumed to be in compliance with the current standard.

Costs associated with compliance at the 0.5, 0.2 and 0.1 mg/m^3 (TWA) (TWA) are shown as the increments required for compliance at those exposure levels assuming compliance with the current regulations, where applicable.

a. *Yarn Production*

1) *Engineering Controls*

For engineering controls, capital costs include the purchase price of the control systems, labor and materials required for the installation of the control systems, and costs associated with building and utilities modification required for the installation of the control systems. Operation and maintenance costs include the labor and materials required for the day-to-day operation of the control system, including repair parts and filter replacement. Energy costs, expressed as kilowatt hours, are reported separately and reflect the incremental increase in energy consumption resulting from the operation of the control system and the increased load on existing air conditioning systems. Additional labor requirements (man-hours) to operate and maintain the control system are also pre-

sented. These cost elements are integrated in estimating annualized costs in the economic analysis of Chapter VI.

Engineering costs were initially computed on the basis of cost per cubic foot per minute (CMF) of air required to control dust generation from yarn production and processing equipment. These were then converted to a per machine basis, and subsequently to a cost per pound of raw cotton processed through the equipment. Data used in determining costs were obtained from control system vendors, textile plants in which control systems are in operation, and from data published by the R. S. Means Company pertaining to the costs of various types of construction. Table V-1 contains the basic cost data by equipment type for yarn mills. Details as to how these data were developed are presented in Appendix B.

Equipment inventory data were obtained from U.S. Bureau of Census publications. Equipment capacities and throughputs were obtained from various literature sources. A summary of these data is shown in Table V-2. Details as to how the data in Table V-2 were generated also appear in Appendix B.

In order to provide estimates of the cost of engineering controls for yarn manufacturing processes to achieve 0.1 mg/m^3 limits, it was necessary to extrapolate from the costs for less stringent controls. This procedure is valid as a means of providing a first estimate of cost because (a) the control techniques postulated to achieve the 0.1 mg/m^3 limit are essentially extensions of the techniques used for lesser control, i.e., ventilation and air filtration, and (b) the cost data for controls at 1.0, 0.5, and 0.2 mg/m^3, as well as RTI's experience with similar controls in other applications, indicates that there is a reasonably stable functional relationship between control cost and level of control. Mathematically, this calculation, for any machine type, is as follows:

$$\frac{\frac{Z-Y}{0.3}}{\frac{Y-X}{0.5}} = \frac{\frac{U-Z}{0.1}}{\frac{Z-Y}{0.3}},$$

where: X = control cost at the 1.0 mg/m³ limit,
Y = control cost at the 0.5 mg/m³ limit,
Z = control cost at the 0.2 mg/m³ limit, and
U = control cost at the 0.1 mg/m² limit.

Solving for U gives the expression:

$$U = \frac{5}{9} \cdot \frac{(Z-Y)^2}{Y-X} + Z.$$

The incremental control cost at the 0.1 mg/m³ limit, therefore, is U - X.

* * * * *

3) *Overall Industry Costs*

Industry-wide costs, initial and recurring, are shown in Table V-5. These costs are based on applying feasible controls on all cotton/yarn equipment regardless of type of fiber being processed. Exclusion of equipment processing man-made fibers only could reduce these costs by as much as 30 percent. Presumably, a mill processing synthetic fibers exclusively will not be subject to regulation under the proposed standard. It is not clear, on the other hand, just how the proposed standard will be applied in mills that process both cotton and synthetics. The equipment used in both processes is essentially the same and is convertible from cotton to synthetics and vice versa. The conservative estimate was made, therefore, that controls would be applied to all the production equipment in mills processing cotton and cotton-synthetic blends, even if part of their product is pure synthetic.

Costs per pound of raw cotton are shown in Table V-6; manpower requirements in Table V-7. Where a range of costs is presented, the lower figure reflects the cost of controlling equipment on which cotton or cotton blends is processed; the higher figure reflects the cost of controlling all yarn processing equipment regardless of fiber being processed.

* * * * *

2) *Weaving*

a) *Engineering Controls*

Cost estimates for engineering controls for yarn processing equipment in weaving mills were obtained by soliciting estimates from vendors of dust control equipment. Costs were estimated using the same analytical steps as described for the yarn production industry (See p. V-10).

Table V-9 gives the ventilation requirements to control the median dust concentrations to 0.5 and 0.2 mg/m^3 (V.E.), and gives the cost per machine, the annual maintenance and operating costs, and the annual energy consumption for dust control systems for the processes indicated. As indicated in Table V-9, no controls are estimated to be required in twisting, weaving and warping to achieve a median dust concentration of 0.5 mg/m^3 (V.E.).

* * * * *

Additionally, based on vendor data, it is estimated that dust control systems for winding and spooling would be required in only 20 percent of the installations to achieve 0.5 mg/m^3 (V.E.). These installations are those in which the yarn being processed was manufactured from very low quality cotton or which for some other reason have a greater than average dust problem. To estimate the cost per machine for dust control systems, the costs obtained from vendor data were multiplied by the estimated fraction of installations which would require dust control

Table V-5. Estimated Incremental Industry-Wide Initial and Recurring Costs to Achieve Permissible Exposure Limits: Yarn Production

Type of Equipment	Initial Costs [1] (Millions of Dollars)			Recurring Costs (Millions of Dollars)		
	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Control Equipment[2]	185.2	879.8	2510.1	3.7	10.1	16.2
Opening and Cleaning	(17.4)	(63.3)	(131.6)	(0.4)	(0.9)	1.4
Cards	(23.1)	(172.7)	(709.7)	(0.5)	(1.5)	2.7
Draw Frames	(7.1)	(39.9)	(124.9)	(0.1)	(0.4)	0.7
Combs	(-)	(7.6)	(10.1)	(-)	(0.1)	0.1
Roving	(38.3)	(100.0)	(155.3)	(0.3)	(1.0)	1.8
Spinning Frames	(99.3)	(496.3)	(1378.5)	(2.4)	(6.2)	9.5
Energy Costs[3]	-	-	-	18.5 [20.9]	61.5 [69.5]	134.3 [151.7]
Medical Surveillance	1.2	1.2	1.2	1.2	1.2	1.2
Environmental Monitoring	4.5	4.5	4.5	0.4	0.4	0.4
Posting	0.1	0.1	0.1	-	-	-
Respirator Program[4]	-	-		1.0	1.0	1.0
Total[3]	190.9 [215.7]	885.6 [999.8]	2515.8 [2841.2]	24.7 [27.7]	74.1 [82.8]	153.0 [174.1]

[1] Includes Capital Equipment costs, and one-time training and indoctrination costs.

[2] Controls required for all cotton systems equipment regardless of fiber processed.

[3] Costs shown in brackets [ ] are based on 1972 raw cotton consumption of 7,725 bales (480 lb/bale). These costs were entered into the Input-Output model in Chapter VI to be consistent with the constraints of that model. All other costs shown are based on 1973 raw cotton consumption, the latest data available.

[4] Costs during pre-compliance period, assuming zero control, pending installation of engineering controls. After engineering controls are operating, recurring costs are $910,000 for all proposed standards.

systems. Because of this, the cost figures appear quite low. This method of presenting costs was chosen to permit total industry costs to be obtained by multiplying the figures in the table by the total equipment in place. A similar discussion applies to the figures given for the 0.2 mg/m^3 exposure limit. In this case, based on vendor supplied data, controls are estimated to be required in 80 percent of all installations. Installations not requiring controls are those which process yarn made from very high quality cotton. Consequently, the fraction which requires dust control systems is much greater than for the 0.5 mg/m^3 limit. Data on the number of units of each piece of equipment now installed in the industry, shown in Table V-10, were obtained from [3] and [4].

Costs for weaving looms are based on engineering controls estimated to be applicable to the operation. For costing purposes, these consist of local exhaust ventilation systems over the area of the loom where the shuttle passes back and forth. It is estimated that a hood for this application would need to be aproximately two feet by five feet, based on an

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estimated average loom width of 54 inches. It is further estimated that an air velocity of 200 feet per minute at the face of the hood would be needed to adequately capture the dust, which results in a requirement for 2,000 cfm per loom. The costs per cfm for application of hoods in such systems are estimated to be about the same as in the yarn production industry. The figure used for determining costs was $3.00 per cfm. Using this figure and an air requirement of 2,000 cfm along with the estimated 209,792 looms [4] processing cotton or blends of polyester and cotton, a total industry capital cost of $1,258.75 million is derived. Annual operating and maintenance costs are estimated at 3 percent of capital costs, or $37.76 million. Energy consumption is estimated at 12.5 Kwh/

Table V-11. Total Industry Costs For Engineering Controls (Weaving)

Equipment Type	0.5 mg/m^3				0.2 mg/m^3				0.1 mg/m^3			
	Capital ($\$10^6$)	Maintenance and Operations ($\$10^3$/yr)	Energy (10^6 Kwh/yr)	Labor (man-hrs/yr)	Capital ($\$10^6$)	Maintenance and Operations ($\$10^3$/yr)	Energy (10^6 Kwh/yr)	Labor (man-hrs/yr)	Capital ($\$10^6$)	Maintenance and Operations ($\$10^3$/yr)	Energy (10^6 Kwh/yr)	Labor (man-hrs/yr)
Winders	1.620	11.267	8.350	1,609	6.265	54.599	31.010	3,900	17,794	155.07	88.32	11,075
Spoolers	6.088	45.577	31.383	6,511	35.306	351.60	175.147	50,510	100.270	999.53	497.42	142,645
Twisters	----	----	----	----	47.464	433.36	237.320	61,908	134.798	1,231.60	673.99	175,819
Warpers	----	----	----	----	38.702	468.50	269.291	66,928	109.913	1,330.53	764.78	190,076
Looms	----	----	----	----	1,258.75	07,762.56	5,244.80	539,465	3,574.86	107,245.67	14,895.23	1,532,081

cfm/yr., which is the approximate average of systems in the yarn production industry at the 0.2 mg/m³ (V.E.) level. Cost estimates for the 0.1 mg/m³ (V.E.) level were obtained by assuming the increment over the costs of 0.2 is equal to that determined for the yarn production industry. The costs obtained for each level are given in Table V-11.

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The Long-term Arrangement Regarding International Trade in Cotton Textiles (LTA) provided the vehicle for import quotas on cotton textiles and apparel and was of major importance for a number of years. The sharp rise of man-made fiber products in the late 1960's led to expanded trade agreements in 1971, and finally to the Multi-Fiber Arrangement Regarding International Trade in Textiles (MFA), which dealt with cotton, wool and man-made fiber products. These arrangements have tended to smother the effects of a small change in the relative prices of domestic versus foreign textile products [See Section 10 of Appendix C.I].

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4) *Impact of OSHA Cost-Related Cotton Yarn Price Increases*

An important intermediate step in determining the final impact is to determine the impact upon plant profitability of the different exposure limits. This examination leads to other considerations such as industry-wide price increases resulting from control expenditures and the availability of labor force, energy and capital for investment in control equipment. Estimations of potential plant closures also resulted from this analysis. This analysis relies upon the assumption that the companies affected by the regulations will pass on fully their increased costs via price increases and thus escape the cost burden of the proposed OSHA regulation. However,

Table VI-5. Additional Installed and Annualized Compliance Costs Per Dollar of Sales

SIC	Exposure Limit mg/m^3	Value of Industry Shipments ($10^6)	Dollars/Dollar of Sales*				
			Installed Costs	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
2211		2660.6					
	0.5		.0419	.0067	.0014	.0041	.0122
	0.2		.1943	.0312	.0030	.0134	.0477
	0.1		.5525	.0888	.0046	.0291	.1225
2221		3856.3					
	0.5		.0099	.0016	.0003	.0010	.0029
	0.2		.0459	.0074	.0007	.0032	.0113
	0.1		.1305	.0210	.0011	.0069	.0289
2281		2250.6					
	0.5		.0241	.0039	.0008	.0023	.0070
	0.2		.1119	.0180	.0018	.0077	.0275
	0.1		.3181	.0511	.0026	.0168	.0705
2257		2808.8					
	0.5		.0012	.0002	.00004	.0001	.0004
	0.2		.0063	.0010	.00009	.0004	.0015
	0.1		.0188	.0030	.00013	.0008	.0040
2284		345.4					
	0.5		.0063	.0010	.0002	.0006	.0019
	0.2		.0328	.0053	.0005	.0022	.0079
	0.1		.0981	.0158	.0007	.0043	.0208
2296		685.1					
	0.5		.0032	.0005	.0001	.0003	.0009
	0.2		.0142	.0023	.0002	.0010	.0035
	0.1		.0392	.0063	.0003	.0022	.0088
TOTAL		12606.8					
	0.5		.0168	.0027	.0005	.0016	.0049
	0.2		.0781	.0126	.0012	.0054	.0192
	0.1		.2223	.0357	.0018	.0117	.0492

*Average compliance costs per dollar of sale are obtained by dividing the total compliance costs shown in Table VI-4a by value of shipments for each SIC sector.

Source: Costs and charges calculated based on Table VI-4a and Table C-2 of Appendix C.

they would face the contractions of demand for their products due to price increases.

In order to estimate the potential cotton yarn price increase, it is necessary to estimate the rates of return on investment, both before and after new exposure limits, for each of the six industry sectors. The level of return on investment after implementation and the relative change in this level from the pre-control level are the bases upon which determinations of adverse economic impact have been made. It is assumed that firms in these industries will attempt to maintain the pre-compliance rate of return on investment, and the average price level in the six industries would increase sufficiently to maintain the pre-compliance rate of return on investment. Two approaches other than the rate of return approach used here may appear reasonable: (1) raising output prices in the same proportion as costs increase (a simple cost pass-through approach) or, (2) increasing output prices after compliance to the level required to maintain earnings per share of common stock (earnings per share approach). However, the rate of return approach is preferred over the simple cost pass-through approach because, as will be shown later, the latter under estimates the compliance cost-related output price increases. As for the earnings per share approach, data problems are often prohibitive. For example, it could not be assumed that firms in these industries would attempt to maintain profits per share of common stock, since adequate data were not available on privately owned small firms.

* * * * *

Table VI-8 summarizes the estimated change in profitability, measured in dollars per dollar of industry shipments, as a result of incurring three different levels of exposure limit compliance costs. The first row of Table VI-8 shows the pre-implementation profitability levels, which are assumed to be applicable to all six textile in-

Table VI-8. Financial Impact of OSHA Cotton Dust Exposure Limits
($/Dollar of Sale)

SIC	Exposure Limit mg/m^3	Total Assets	Total Cost	Profit After Tax	Rate of Return to Investment (ROI)	Price Increase Required to Maintain Pre-Control ROI
Precontrol	1.0	0.612	0.954	0.025	0.041	
2211	0.5	0.654	0.966	0.0184	0.028	0.0155
	0.2	0.806	1.002	-0.0009	-0.001	0.0625
	0.1	1.165	1.077	-0.042	-0.036	0.1644
2221	0.5	0.622	0.957	0.0234	0.038	0.0038
	0.2	0.658	0.965	0.0189	0.029	0.0149
	0.1	0.742	0.983	0.0093	0.012	0.0389
2281	0.5	0.636	0.961	0.0212	0.033	0.0090
	0.2	0.724	0.981	0.0101	0.014	0.0361
	0.1	0.930	1.025	-0.0133	-0.014	0.0947
2257	0.5	0.613	0.954	0.0248	0.040	0.0006
	0.2	0.618	0.956	0.0242	0.039	0.0022
	0.1	0.631	0.958	0.0228	0.036	0.0056
2284	0.5	0.618	0.956	0.0240	0.039	0.0025
	0.2	0.645	0.962	0.0207	0.032	0.0106
	0.1	0.710	0.975	0.0137	0.019	0.0283
2296	0.5	0.615	0.955	0.0245	0.040	0.0013
	0.2	0.626	0.958	0.0231	0.037	0.0048
	0.1	0.651	0.963	0.0202	0.031	0.0119

Sources: Calculations are based on data in Tables VI-5 and VI-7a.

dustry sectors. In order to determine the change in profitability resulting from the estimated control costs, the installed cost requirements per dollar of sales (TIC) for each of these sectors are added to the pre-control total asset (PRAS), 61.2 cents, and total annualized costs (TAC) are added to the pre-control total costs (PRTC), 95.4 cents. From these increased values, total assets and total costs, the post-standard returns on investment are calculated and shown in Table VI-8 (ROI column) for each of the six sectors for three exposure limits. The last column of Table VI-8 shows the average price increase per dollar of sales (PINC) required to maintain pre-control rate of returns on investment, (PRROI). The above calculation can be summarized as follows:

Since by definition,

$$\text{Rate of Return} = \frac{(\text{Price-Cost}) \times (1-\text{tax Rate})}{\text{Assets}} = \frac{\text{Net Profit}}{\text{Assets}} \qquad (1)$$

one may write

$$\text{PRROI} = \frac{[(P + \text{PINC}) - (\text{PRTC} + \text{TAC})] \times (1 - \text{Tax Rate})}{\text{PRAS} + \text{TIC}}, \qquad (2)$$

or

$$\text{PINC} = \frac{\text{PRROI}\,(\text{PRAS} + \text{TIC})}{(1 - \text{Tax Rate})} + (\text{PRTC} + \text{TAC}) - P. \qquad (3)$$

where P is pre-control output price. P is unity for the computations in Table VI-8 and P equals the average price of cotton yarn ($/1b) shown at the third column of Table VI-9 for the computations in Table VI-9.

The price increases required for SIC Code 2211 (Weaving Mills, Cotton) are 1.6, 6.3 and 16.4 cents per dollar of sales for the 0.5, 0.2 and 0.1 mg/m^3 exposure limits, respectively. Similarly, 0.9, 3.6 and 9.5 cents in price increases are required for SIC Code 2281 (Yarn Mills, Except Wool). SIC Code 2221 (Weaving Mills, Manmade Fiber and Silk) requires 0.4 cents, 1.5 cents and 3.9 cents to maintain pre-control rates of return, while SIC

Table VI-9. Financial Impact of OSHA Cotton Dust Exposure Limits
($/Pound of Cotton Yarn Produced)

SIC	Exposure Limit mg/m^3	Total Assets	Average Price of Cotton Yarn ($/lb.)	Total Cost	Profit After Tax	Rate of Return to Investment (ROI)	Price Increase Required to Maintain Pre-Control ROI ($/lb.)	Percent of Increase
2211	0.5	0.775	1.176	1.138	.0207	.0267	.020	1.7
	0.2	0.975	1.176	1.185	-.0046	-.0047	.082	7.0
	0.1	1.445	1.176	1.283	-.0580	-.0401	.216	18.3
2221	0.5	0.775	1.176	1.138	.0207	.0267	.020	1.7
	0.2	0.975	1.176	1.185	-.0046	-.0047	.082	7.0
	0.1	1.445	1.176	1.283	-.0580	-.0267	.216	18.3
2281	0.5	0.775	1.176	1.138	.0207	-.0267	.020	1.7
	0.2	0.975	1.176	1.185	-.0046	-.0047	.082	7.0
	0.1	1.445	1.176	1.283	-.0580	-.0401	.216	18.3
2257	0.5	0.972	1.483	1.434	.0267	.0274	.024	1.6
	0.2	1.242	1.483	1.495	-.0068	-.0054	.106	7.2
	0.1	1.908	1.483	1.626	-.0778	-.0408	.287	19.4
2284	0.5	0.972	1.483	1.434	.0267	.0274	.024	1.6
	0.2	1.242	1.483	1.495	-.0068	-.0054	.106	7.2
	0.1	1.908	1.483	1.626	-.0778	-.0408	.287	19.4
2296	0.5	0.679	1.023	0.991	.0173	.0255	.019	1.9
	0.2	0.863	1.023	1.035	-.0064	-.0074	.077	7.5
	0.1	1.281	1.023	1.123	-.0545	-.0425	.197	19.2

Sources: Calculations are based on data in Tables VI-3 and VI-7a.

Code 2296 (Tire Cord and Fabric) requires the lowest price increases, 0.1 cents, 0.5 cents and 1.2 cents per dollar of sales, to comply with the 0.5, 0.2 and 0.1 mg/m^3 exposure limits, respectively, and to maintain the pre-control rate of return. It is important to note that the price increases per dollar of sales shown in Table VI-8 are higher than the total annualized costs (per dollar of sales) shown in Table VI-5 for all three exposure limits for all six of the SIC sectors. As mentioned previously, this is why the rate of return approach is preferred to the simple cost pass-through approach which assumes the price increases per dollar of sales equals the total annualized cost per dollar of sales. Moreover, it is important to note that price increases required to maintain pre-control ROI for the 0.1 mg/m^3 exposure limit are 200 - 300 percent of those required at the 0.2 mg/m^3 exposure limit and 900 - 1000 percent of those required by the 0.5 mg/m^3 exposure limit. Additionally, in the absence of price increases, profit-after-taxes and ROI would be very small or negative in some cases.

Table VI-9 represents similar computations as above, but they are estimated per pound of cotton yarn produced. The average prices of cotton yarn produced in each sector are estimated on the basis of the observation that SIC Codes 2257 and 2284 typically produce and consume a higher quality of yarn than the other sectors and SIC Code 2296 consumes a lower quality of yarn. SIC Codes 2211 and 2221 are assumed to produce and consume a combination of several qualities of yarn, similar to that produced by SIC Code 2281.

Table VI-9 indicates, for example, that for SIC Codes 2211, 2221, and 2281, 2.0, 8.2 and 21.6 cents are required per pound of cotton yarn produced to maintain the pre-control return on investment after exposure limits of 0.5, 0.2, and 0.1 mg/m^3 are imposed. SIC Codes 2257 and 2284 require 2.4, 10.6 and 28.7 cents per pound of

yarn to maintain pre-control rates of return and to satisfy the three exposure limits. SIC Code 2296 requires 1.9, 7.7 and 19.7 cents. In this computation, the production losses in yarn spinning were ignored. It is worth noting that all the sectors had negative "profits after taxes" for 0.2 and 0.1 mg/m^3 exposure limits, if no price increases are assumed.

To clarify the manner by which the figures in Tables VI-8 and VI-9 were generated from previous tables, the calculations for the 0.2 mg/m^3 exposure limit for SIC Code 2211 are detailed in the following example. Applying compliance cost data (per dollar of sales) from Table VI-5 and pre-control financial parameters shown at the first column of Table VI-7a and at the first row of Table VI-8 to the equation (2) in this section results in:

$$0.041 = \frac{[(1 + \text{PINC}) - (0.954 + 0.0477)] \times (1 - 0.4565)}{0.612 + 0.1943}$$

where the Tax Rate $= \dfrac{\text{Income Tax}}{\text{Profit Before Taxes}} = \dfrac{0.021}{0.046} =$ 0.4565, from Table VI-7a and P is set equal to 1. Solving this equation results in PINC = 0.0625 (which is shown in the last column of Table VI-8).

To obtain the figures in Table VI-9, P is set equal to 1.176 for SIC Code 2211 and PRTC and PRAS in equation (2) are multiplied by 1.176. The value of TAC and TIC were taken from Table VI-3 as below:

$$0.041 = \frac{[(1.176 + \text{PINC}) - (0.954 \times 1.176 + 0.0626)] \times (1 - 0.4565)}{0.612 \times 1.176 + 0.255}$$

or

PINC = 0.082 which is shown in the 7th column of Table VI-9. The last column of Table VI-9 is obtained by $\dfrac{0.082}{1.176} \times 100$.

Equation (2) holds only when one assumes the price demand elasticity for the sector's output, i.e. cotton yarn, is zero. One important point to note here is that the prime demand elasticity is for the derived input demand (as opposed to consumer demand) because the outputs of the sector, i.e., cotton yarns, are used as inputs to other producing sectors. As is well known (from Marshall) the derived input demand elasticities depend upon four different factors: elasticity of input substitution; supply elasticity of inputs; share of that input cost in total production cost; and output demand elasticities for the products which are produced using these inputs. The deailed data on these factors are not available and to estimate the accurate derived demand elasticity is beyond the scope of this study. Therefore, it was decided to adopt an extreme assumption of zero price demand elasticity in computing the post-control price increases. However, it is of great interest to investigate how much bias the estimated results will have due to the assumption of zero price elasticity of demand when the real elasticity is actually non-zero. More accurately, equation (2) can be rewritten as:

$$\text{PROI} = \left[\frac{(P + \text{PINC}) \times (1 - \eta \cdot \text{PINC}) \times \text{PRVL}}{(\text{PRAS} + \text{TIC}) \times \text{PRVL}} - \frac{[\text{PRTC} \times .90 \times (1 - \eta \cdot \text{PINC}) \times \text{PRVL} + \text{PRTC} \times .1 \times \text{PRVL} + \text{TAC} \times \text{PRVL}]}{(\text{PRAS} + \text{TIC}) \times \text{PRVL}} \right] \times (1 - \text{Tax Rate}) \quad (4)$$

where η is the price elasticity of demand for the output of the sector, and PRVL is the pre-control total value of industry shipments.

The basic ideas in equation (4) are that the revenue will be increased by the price increases (P + PINC) but

decreased by the reduction of demand ($1 - \eta$. PINC), and that while total industry variable costs will be reduced by the demand contraction, total industry fixed costs and total industry assets will not be influenced by the demand contraction. It is assumed that 90 percent of the pre-control total costs (PRTC) are variable costs, i.e., 55 percent material costs, 30 percent labor costs and 5 percent other sales costs, and that all of total annualized costs (TAC) are fixed costs. When the demand elasticity, η, is zero equation (4) becomes equation (2). Again, using the value for the 0.2 mg/m^3 exposure limit for SIC Code 2211, the figures corresponding to those in Table VI-8 can be computed for any desired elasticity scenario, such as $\eta = 0.5$ and $\eta = 1.0$. When $\eta = 0.5$,

$$0.041 = \left[\frac{(1 + \text{PINC}) \times (1 - 0.5 \times \text{PINC}) \times 2660.6}{(0.612 + 0.1943) \times 2660.6}\right.$$

$$\left. - \frac{[0.954 \times 0.9 \times (1 - 0.5 \times \text{PINC}) \times 2660.6 + 0.954 \times 0.1 \times 2660.6 + 0.0477 \times 2660.6]}{(0.612 + 0.1943) \times 2660.6}\right]$$

$$\times (1 - 0.4565)$$

or

$$(\text{PINC})^2 - 1.8586 \times \text{PINC} + 0.125 = 0$$

One solution for PINC is 0.07. This implies that if one adopts the assumption of zero demand elasticity when the true demand elasticity is 0.5, the estimated post-control price increase, per dollar of sales, 0.0625 underestimates the real price increase per dollar sales, 0.07, by approximately 10 percent.

Similarly, when $\eta = 1.0$, $(\text{PINC})^2 - 0.8586 \times \text{PINC} + 0.0625 = 0$. The solution for PINC is 0.08, which implies that when the true elasticity is unity, the esti-

mated price increase based on the zero demand elasticity will underestimate the true value by approximately 22 percent.

The above computation indicates that unless the true demand elasticity for the output of the given sector is substantially greater than unity, our impact analysis based on the assumption of zero price elasticity of demand would not be invalidated.

d. *Impact on Market Structure and Marginal Industries*

Even in the extreme case where no significant adverse impact, as measured by profitability, appears to accrue to the industry due to the new limits (assuming that costs are passed on), it is possible that capital availability could be a problem for this industry. Most economic studies of the impact of control standards have considered only the capital cost of new equipment and the operating and maintenance costs of those devices. Largely ignored are the capital fund and capacity shortages resulting from these costs and the impact these shortages have on both national and regional economic growth. The outlay of funds for standard compliance capital will reduce the cash available for plant and equipment expenditures such as for replacement of obsolete equipment and for expansion to desired levels of production capacity.

As noted in Appendix C, which describes the industry economic environment, the capacity utilization rate has been considerably lower for the textile industry than for many other industrial sectors. Therefore, the production capacity shortages due to the compliance capital requirements are not likely to be severe for this industry. However, as noted in a previous section, the major impact of the proposed cotton dust exposure limits

for this industry will come from the additional capital requirements rather than from the production cost increases due to the annualized compliance costs. The actual impact will depend in part upon how the capital costs are financed (long-term debt or equity) and the length of time over which the compliance investment is spread. The shorter the period over which the investment is spread (i.e., the heavier the annual purchase of compliance equipment are), the larger the potential impact upon the capital fund market and interest rates. Heavy short-term investments in compliance expenditures would cause the external capital funds available to companies to become relatively more scarce and, in turn, interest rate companies would have to pay on such funds would increase.

Since the textile industry is composed of a heterogeneous group of companies, it is not very meaningful to discuss whether or not the capital requirement of 2802.7 million dollars for the 0.1 mg/m^3 exposure limit, for example, can be financed at the industry level. As shown in Table VI-10, the financial strength indicated by the rates of "profit after tax" or "return on investment" varies significantly among the different size classes of textile companies; the rate of "profit after tax" varies directly with the size class of companies, ranging from losses for many of the smaller firms to about 4.6 cents per dollar of sales for those in the largest class. Therefore, it is important to consider the potential financing problems arising from the capital requirements of the proposed OSHA exposure limits at the company level, and as will be discussed shortly, the ability to finance the compliance capital requirement will be used as a major decision rule in predicting possible plant closures. The engineering information obtained by RTI revealed that there is no significant variation in the compliance capital costs and annualized costs per unit of output among different size classes of textile mills (control de-

Table VI-10. Comparison of Basic Financial Parameters Among Different Size Classes of Textile Companies (Unit = $/Dollar of Sales)*

Annual Sales	Total Assets	Total Costs	Profit Before Taxes	Profit After Taxes	Rate of Return to Investment
Average, All Companies	0.612	0.954	0.046	0.025	0.041
Under $25,000	10.780	2.148	-1.148	-1.199	-0.111
$ 25,000 – $ 50,000	0.733	1.017	-0.017	-0.0192	-0.026
50,000 – 100,000	0.638	1.030	-0.030	-0.036	-0.057
100,000 – 500,000	0.534	0.988	0.012	0.004	0.009
500,000 – 1,000,000	0.439	0.976	0.024	0.015	0.034
1,000,000 – 5,000,000	0.465	0.965	0.035	0.019	0.040
5,000,000 – 10,000,000	0.478	0.961	0.039	0.020	0.042
10,000,000 – 50,000,000	0.540	0.954	0.046	0.025	0.046
50,000,000 – 100,000,000	0.691	0.949	0.051	0.028	0.040
100,000,000 – 250,000,000	0.765	0.949	0.051	0.028	0.037
250,000,000 – 500,000,000	0.936	0.934	0.066	0.038	0.040
500,000,000 – 1,000,000,000	0.622	0.954	0.046	0.026	0.042
Over $1,000,000,000	0.715	0.916	0.084	0.046	0.065

*The financial parameters by size class of firms were obtained by averaging data for the 5 year period 1965-66 and 1968-70 and by subsequently inflating those results to 1974 levels. This inflation was accomplished by taking financial parameter data for the total industry between 1970 and 1974 and applying the resulting ratio to all size classes.

Source: Internal Revenue Service, Corporation Income Tax Returns

vices are applied to each piece of equipment and there are no significant economies of scale). Therefore, substantial differences are not expected in relative changes of post-control profitability from pre-control ones due to different production cost increases among the different size classes of companies.

The ratio of capital requirements to profit after taxes is used in this study as a measure of the ability of each class of textile company to finance the compliance capital costs. If the ratio is substantially larger for a size class than those for most other size classes, then those companies belonging to this size class are likely to have capital shortage problems and probably will be forced to rely heavily on external debt financing, and thus pay higher capital costs. Therefore, rates of return to investment for these companies will be further depressed.

One realistic and convincing theory of investment is that the level of investment expenditures is proportional to profits[7]. Two alternative rationalizations of this theory can be offered. First, realized profits measure expected future profits and so it is almost a tautology to say that investment is governed by profits expectations. Second, the rate of investment may be constrained by the supply of funds. In reality, some kind of financial constraints operate at all times; the cost of funds schedule becomes highly inelastic when internal funds are exhausted. The cash available for investment, which is the source for internal financing, is usually measured by the sum of retained earnings and depreciation allowances. However, there is a strong recent claim by corporate finance analysts that the depreciation on plant and equipment, which are subtracted from gross profits before computing corporate tax bills, cannot begin to cover the cost of replacing production capacity[8]. This underdepreciation is largely due to the fact that such production capacity will be very expensive to replace because

of recent high inflation and that depreciation allowances are based on original purchase costs.

The above discussion implies that the cash available for both capacity expansion investment and nonproductive capital investment such as capital costs for compliance with the standard should come from the retained earnings. Therefore, the profit after tax should be a good measure for the flow of internal funds available for investment, remembering that the average share of retained earnings out of profit after taxes has remained stable over time for the textile industry. The above analysis indicates that as the ratio of compliance capital costs to profits after taxes is larger, the company is likely to face more severe difficulty in financing the compliance capital. First, because the smaller profit after taxes predict the poor expected future profits, and second, because the smaller profit after taxes indicates the smaller flow of internal funds available for investment.

Table VI-11 presents the ratio of capital costs for compliance to profit after taxes for each size class of company within each of the six SIC sectors and for three exposure limits based on the financial data by company size presented in Table VI-10. The profits after taxes are calculated assuming that prices of industry outputs have been raised enough to maintain pre-control return on investment as shown in Table VI-8. It seems clear from Table VI-11 that the greatest difficulties in financing capital costs for compliance will fall on the two sectors, SIC Code 2211 (Weaving Mills, Cotton) and SIC Code 2281 (Yarn Mills, Except Wool). The exposure limit of 0.1 mg/m^3 will require compliance capital expenditures in excess of 700 percent of annual profits after taxes for all the size classes of companies in SIC Code 2211 and in excess of 500 percent of profit after taxes for all the size classes of companies in SIC Code 2281. The exposure limit of 0.2 mg/m^2 will require compliance capital expenditures in excess of 300 percent of

annual profit after taxes for all the size classes of companies in SIC Code 2211 and substantial expenditures in SIC Code 2281 as well. However, the limit of 0.5 mg/m^3 reveals significantly smaller ratios for all sectors except some smaller size classes in SIC Code 2211, and the ratios are less than unity for this exposure limit for all size classes of firms in each of the six SIC sectors, except SIC Codes 2211 and 2281, and for the medium to small classes of SIC Code 2221 and 2284.

The ratios for the 0.1 mg/m^3 exposure limit are extremely large for SIC Codes 2211 and 2281, ranging from 7.95 (compliance capital costs equal to 795 percent of profits after taxes) to 28.96 for SIC 2211, ignoring three smallest size classes for which pre-control profits were negative. The comparable range for SIC 2281 is from 5.32 to 24.81. For the 0.1 mg/m^3 exposure limit, even SIC Codes 2221 and 2284 reveal large ratios ranging from 2.51 to 16.73 for SIC Code 2221 and from 1.94 to 14.19 for SIC Code 2284.

The ratios for the 0.2 mg/m^3 exposure limit are also large for SIC Codes 2211 and 2281, ranging from 3.56 to 20.46 for SIC 2211. The comparable range for SIC 2281 is from 2.19 to 15.32, and for SIC Code 2221 the range is 0.95 to 8.29. The ratio for this exposure limit exceeds unity for all but the largest size class in SIC Codes 2221 and 2284, and is below unity for nearly all size classes in SIC Codes 2257 and 2296. In all cases, ignoring negative profits (for which the conclusion is clear), the ratios generally decline as company size increases, i.e. the ratios are larger for small size classes than for larger size classes. Also, the differences in the size of ratios between classes is quite pronounced, suggesting that the difficulty of financing the compliance capital costs within a given SIC sector is inversely related to size of firm. These observations are true for each of the 0.5 mg/m^3, 0.2 mg/m^3 and 0.1 mg/m^3 limits, but the impact is much more pronounced at 0.1 mg/m^3 level.

Table VI-11. Ratios of Compliance Capital Costs to Profit After Tax, by SIC and Exposure Level*

Annual Sales	SIC 2211			SIC 2221			SIC 2281		
	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Average, All Companies	1.56	5.88	11.57	0.39	1.70	4.29	0.92	3.77	8.34
Under $25,000	-0.04	- 0.16	- 0.48	-0.01	-0.04	- 0.11	-0.02	- 0.09	-0.27
$ 25,000 - $ 50,000	-2.71	-79.15	19.61	-0.54	-3.04	-16.56	-1.42	-11.82	38.92
50,000 - 100,000	-1.30	-10.63	37.82	-0.28	-1.44	- 5.41	-0.71	- 4.34	-46.29
100,000 - 500,000	7.72	20.46	28.96	2.16	8.29	16.73	4.85	15.32	24.81
500,000 - 1,000,000	2.46	8.05	13.54	0.64	2.66	6.16	1.48	5.51	10.63
1,000,000 - 5,000,000	2.03	7.24	13.29	0.51	2.21	5.39	1.21	4.77	9.96
5,000,000 - 10,000,000	1.92	7.00	13.26	0.48	2.09	5.16	1.14	4.55	9.76
10,000,000 - 50,000,000	1.57	5.92	11.67	0.39	1.71	4.31	0.93	3.79	8.40
50,000,000 - 100,000,000	1.42	5.45	10.96	0.35	1.55	3.95	0.84	3.46	7.80
100,000,000 - 250,000,000	1.40	5.34	10.75	0.35	1.52	3.87	0.82	3.40	7.65
250,000,000 - 500,000,000	1.06	4.23	9.02	0.26	1.16	3.02	0.62	2.64	6.21
500,000,000 - 1,000,000,000	1.50	5.64	11.08	0.37	1.63	4.11	0.89	3.62	7.99
Over $1,000,000,000	0.87	3.56	7.95	0.21	0.95	2.51	0.51	2.19	5.32

Annual Sales	SIC 2257			SIC 2284			SIC 2296		
	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Average, All Companies	0.05	0.25	0.73	0.25	1.24	3.37	0.13	0.55	1.47
Under $25,000	-0.001	-0.01	-0.02	-0.01	-0.03	-0.08	-0.003	-0.01	-0.03
$ 25,000 - $ 50,000	-0.06	-0.34	-1.08	-0.34	-2.03	-9.16	-0.17	-0.80	-2.50
50,000 - 100,000	0.03	-0.18	-0.55	-0.18	-1.00	-3.61	-0.09	-0.41	-1.21
100,000 - 500,000	0.28	1.40	3.89	1.41	6.29	14.19	0.73	3.01	7.31
500,000 - 1,000,000	0.08	0.41	1.17	0.41	1.97	5.00	0.21	0.90	2.32
1,000,000 - 5,000,000	0.06	0.33	0.96	0.33	1.62	4.29	0.17	0.73	1.91
5,000,000 - 10,000,000	0.06	0.31	0.90	0.31	1.52	4.09	0.16	0.68	1.80
10,000,000 - 50,000,000	0.05	0.25	0.73	0.25	1.24	3.39	0.13	0.55	1.48
50,000,000 - 100,000,000	0.04	0.23	0.66	0.23	1.13	3.09	0.11	0.50	1.34
100,000,000 - 250,000,000	0.04	0.22	0.65	0.22	1.10	3.03	0.11	0.49	1.31
250,000,000 - 500,000,000	0.03	0.17	0.49	0.17	0.84	2.35	0.08	0.37	1.00
500,000,000 - 1,000,000,000	0.05	0.24	0.70	0.24	1.19	3.24	0.12	0.53	1.41
Over $1,000,000,000	0.03	0.13	0.40	0.13	0.68	1.94	0.07	0.30	.81

*The negative ratios for the three smallest size classes are due to the negative value of pre-control profit after tax as shown in Table VI-10.
Sources: Tables VI-8 and VI-10.

The evidence presented in Table VI-11 clearly indicates that unless the compliance capital investments are spread over a substantial number of years, all the companies engaged heavily in cotton yarn production will face severe difficulty in financing compliance capital for the 0.2 mg/m^3 and 0.1 mg/m^3 exposure limits and the difficulty will be more intense for smaller companies. However, the above analysis only points out the relative difficulties among size classes of companies and industry sectors. It fails to identify specifically which plants are likely to be closed due to compliance capital requirements. It is impossible to state with any certainty that a certain plant might close as a result of the exposure limits. It can only be recognized that the possibility of closure does exist, due to the difficulty in financing capital costs for the 0.2 mg/m^3 and 0.1 mg/m^3 exposure limits.

Two sectors, SIC Code 2211 (Weaving Mills, Cotton) and SIC Code 2281 (Yarn Mills, Except Wool), in particular, and to some degree SIC Code 2221 (Weaving Mills, Manmade Fiber and Silk), will have severe problems in acquiring compliance capital necessary to meet the 0.2 mg/m^3 and 0.1 mg/m^3 exposure limits.

Appendix D presents some estimates of financial impacts of OSHA exposure limits for each of 35 publicly-owned major textile companies. However, it should be noted that financial impacts of OSHA exposure limits for these major producers are likely to be substantially different from the minor producers.

Since Table VI-11 clearly indicates that the difficulty of financing the compliance capital costs within a given SIC sector is inversely related to size of firm, the distribution of companies, plants and sales within the major SIC sectors by size of annual sales is presented in Table VI-12. However, it should be hastily pointed out that the information contained in Table VI-12 cannot be

directly linked to Tables VI-10 and VI-11 because while the latter tables are classified by the total annual sales of each company including products which do not belong to the six SIC codes studied, the former table is exclusively classified by annual sales belonging to the SIC sector designated in the column heading. Therefore, any company classified in, for example, the 5-10 million dollar (of SIC 2211) annual sales classification in Table VI-12 should have financial parameters of the annual sales class greater than 5-10 million dollars in Table VI-10, unless that company produces only SIC 2211 products and nothing else.

Thus the information in Table VI-12 should be used with appropriate caution. For example, if some other source of information suggested that all the companies producing SIC Code 2211 products in the less than 5 million dollars (annually) classification would be forced to close their plants due to the compliance capital costs, Table VI-12 indicates that the number of companies in SIC Code 2211 will decrease to less than one-half of the current total number of companies (from 182 to 79 companies) and the production capacity of SIC 2211 will be reduced by 6.4 percent (assuming capacity utilization rates are uniform among different size classes of companies). Furthermore, if all the companies producing less than $10 million of SIC 2211 products annually are forced to close due to the compliance capital requirement, the total number of companies will be reduced from 182 to 45 and production capacity will be reduced by 14.3 percent of the current level of capacity.

* * * *

f. *Employment Impact*

1) *Output Demand Elasticity*

The hypothesized exposure limits may have either one of two effects on producers of cotton yarn and cotton

fabric. First, managers of marginal plants may choose to close their facilities rather than bear the cost of meeting the new cotton dust exposure limits. Second, those plants which remain open, as well as any new entrants into these industries, will incur higher costs, which in turn will necessitate charging higher unit prices to insure continued profitable operations. Quantity demanded will be less at the new higher prices and the industry(s) will contract. The magnitudes of these price increases and the quantity contractions will depend upon the price elasticity of demand and the price elasticity of supply for the products of the industry(s). In the short run, the closing of productive capacity could reduce supply below the new and lower level of supply and demand equilibrium causing a temporary upward pressure on prices, rising above the long-run equilibrium level. Such pressure is not, in all probability, to be expected in the cotton textile industries since these industries have typically experienced excess capacity, and the closing of marginal firms would not reduce the quantity supplied below the equilibrium level. In the absence of excess capacity, new investment would soon absorb, in any event, any excess profit caused by temporary price aberrations. The question remains as to how the market would react.

In order to predict the cotton consumers' responses to price increases, reasonable estimates of price elasticities of demand are necessary for each of the 477 PCE items so that estimates can be made of the previously discussed contraction in demand and the subsequent reduction of production and employment in the cotton yarn producing industries.
used since long-run elasticities were not available except

Direct price elasticities of demand were obtained from *An Investigation of Consumer Demand Elasticities* by Ernst and Ernst[10]. Only the short run elasticities were

for a few industries, and short-run elasticities were available by SIC Code products for the year 1972. When necessary, the estimates of price demand elasticities for PCE groups made by Houthakker and Taylor[11] were also utilized. Estimates of price demand elasticities for the 25 major cotton consuming PCE items are listed in Table VI-14a.

2) *The Contraction of Cotton Yarn Production*

In order to obtain the percentage contraction of demand for each of the 477 PCE items, the price elasticities of demand matched to each of the 477 PCE items were then multiplied by the estimates of percent price increases for each PCE item obtained by the second approach in Section e. Table VI-14b presents estimated declines in final demand for the 25 major cotton consuming PCE items.

Table VI-14b indicates that for the 0.1 mg/m^3 limit the most significant declines in final demand will occur in Men's and Boy's Gloves (43.8%), Tents and Other Canvas Products (22.3%), Thread Mills (11.9%), and Awnings and Tarpaulins (11.0%). The 0.2 mg/m^3 exposure limit results in smaller declines in final demand than does the 0.1 mg/m^3 limit, i.e., the decline in final demand due to the 0.2 mg/m^3 limit is approximately one-third of that due to the 0.1 mg/m^3 limit. Again, declines in final demand due to the 0.5 mg/m^3 limit are relatively insignificant and are approximately one-fourth of those due to the 0.2 mg/m^3 exposure limit.

While the two largest cotton consuming PCE items, Men's and Boy's Apparel (0.4, 1.6 and 4.3 percent declines at the three exposure limits) and Home Furnishings (0.3, 1.3 and 3.5 percent), reveal significant declines in demand, Women's and Children's Apparel (0.04, 0.16 and 0.41 percent) reveal only a minor slackening in final demand.

Table VI-14a. Estimates of Short Run Demand Price Elasticities for 25 Major PCE Items.

PCE Serial Number	PCE Code Number	PCE Item Description	1967 Cotton Consumption (10^6 lbs.)	1967 PCE Expenditures ($\$10^6$)	Estimates of Short Run Price Elasticities
97	20302	Men's and Boys' Apparel	1251.90	9721.9	-2.11
228	50500	Home Furnishings	919.15	2506.1	-0.60
76	20301	Women's and Childrens' Apparel	747.48	15993.5	-0.55
222	50500	Broadwoven Fabric	315.19	422.4	-0.20
176	50400	Carpets and Rugs	95.86	2340.7	-0.30
105	20400	Military Clothing	73.98	124.3	-0.20
99	20302	Men's and Boys' Clothing	62.30	102.0	-4.50
95	20302	Men's and Boys' Hose	60.47	507.4	-1.50
412	90400	Tents and Other Canvas Products	56.42	96.6	-2.40
344	80101	New Passenger Cars	53.09	17972.5	-2.50
227	50500	Curtains and Draperies	45.42	730.7	-0.40
179	50400	Awnings and Tarpaulins	42.41	42.9	-0.70
63	20100	Footwear	39.88	4534.6	-0.19
324	60600	Hospital Services	38.85	9717.0	-0.27
78	20301	Diapers	38.10	166.0	-0.50
175	50400	Blankets	37.70	252.4	-0.20
68	20301	Broadwoven Fabric	36.90	389.8	-0.20
141	50100	Mattresses and Bedsprings	33.39	1120.7	-0.90
60	20100	Rubber Footwear	31.38	693.4	-1.00
264	50600	Abrasive Products	23.67	100.4	-0.47
178	50400	Pillows, Comforters, and Quilts	23.64	198.8	-0.60
73	20301	Hosiery	20.92	1087.6	-1.50
387	90100	Book Publishing	18.21	1681.8	-0.80
223	50500	Thread Mills	16.74	12.9	-0.50
106	20400	Military Accessories	10.06	48.5	-0.50

Source: Ernst and Ernst [10] and Houthakker and Taylor [11].

Table VI-14b. Estimated Declines of Final Demand Due to OSHA Cotton Dust Exposure Limits for PCE Sectors.

PCE Serial Number	PCE Code Number	PCE Item Description	1967 Cotton Consumption (10^6 lbs.)	Percentage Decline of Final Demand Due to OSHA Standards*		
				0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
97	20302	Men's and Boys' Apparel	1251.90	0.40	1.64	4.32
228	50500	Home Furnishings	919.15	0.32	1.33	3.49
76	20301	Women's and Children's Apparel	747.48	0.04	0.16	0.41
222	50500	Broadwoven Fabric	315.19	0.22	0.90	2.37
176	50400	Carpets and Rugs	95.86	0.02	0.07	0.20
105	20400	Military Clothing	73.93	0.17	0.72	1.89
99	20302	Men's and Boys' Gloves	62.30	4.04	16.62	43.77
95	20302	Men's and Boys' Hose	60.47	0.26	1.08	2.84
412	90400	Tents and Other Canvas Products	56.42	2.06	8.45	22.25
344	80101	New Passenger Cars	53.09	0.01	0.04	0.12
227	50500	Curtains and Draperies	45.42	0.04	0.15	0.39
179	50400	Awnings and Tarpaulins	42.41	1.02	4.17	10.99
63	20100	Footwear	39.88	0.002	0.01	0.03
324	60600	Hospital Services	38.85	0.002	0.006	0.02
78	20301	Diapers	38.10	0.17	0.69	1.82
175	50400	Blankets	37.70	0.04	0.18	0.47
68	20301	Broadwoven Fabric	36.90	0.03	0.11	0.30
141	50100	Mattresses and Bedsprings	33.39	0.04	0.16	0.43
60	20100	Rubber Footwear	31.38	0.07	0.28	0.73
264	50600	Abrasive Products	23.67	0.16	0.67	1.76
178	50400	Pillows, Comforters, and Quilts	23.64	0.10	0.43	1.13
73	20301	Hosiery	20.92	0.04	0.17	0.46
387	90100	Book Publishing	18.21	0.01	0.05	0.14
223	50500	Thread Mills	16.74	1.04	4.46	11.92
106	20400	Military Accessories	10.06	0.15	0.63	1.66

*Based on the second approach.

Sources: Cotton Counts Its Customers and RTI Computations. Tables VI-13 and VI-14a.

The resulting estimates of percentage contraction of demand for final products due to the compliance with cotton dust exposure limits are then multiplied by the total cotton yarn consumption of each PCE item to derive the estimates of reductions in cotton yarn demand. These estimates of reductions in cotton yarn demand attributable to each PCE item are aggregated for the total 477 PCE items to obtain the estimate of total contraction of cotton yarn consumption. The estimates indicate that output price increases for each PCE item due to compliance costs will result in a contraction of cotton yarn consumption by 14.0, 57.3 and 151.1 million pounds for 0.5, 0.2 and 0.1 mg/m^3 limits, respectively. These quantities are 0.33, 1.33 and 3.51 percent of the 1967 total mill cotton consumption of 4303 million pounds.

These estimates of the contraction of cotton yarn consumption due to the compliance costs can be cross-checked with an alternative estimation method. NCCA's "Cotton Counts Its Customers, 1969"[9], provides the 1967 cotton consumption data for the major end-use groups and the elasticities of input substitution between cotton and non-cellulosic fiber are available from a USDA inter-fiber study (1974)[12] as shown in Table VI-15.

From the last column of Table VI-9 it can be seen that the cotton/non-cellulosic fiber relative price will be increased by 1.70, 7.0 and 18.3 percent for major SIC sectors 2211, 2221, and 2281 due to the 0.5, 0.2 and 0.1 exposure limits, respectively. Utilizing this information, one can obtain the estimated declines in cotton demand by each major end-user due to interfiber substitution. These results are shown in the last column of Table VI-15. The total declines of cotton yarn consumption due to interfiber substitution at 1967 output levels, which are 17.6, 72.3 and 189.1 million pounds for the three exposure limits, do not vary significantly from the estimates obtained earlier using the output demand elas-

Table VI-15. Demand Effects of Interfiber Substitution at 1967 Levels of Output

End-Use Group	1967 Cotton Consumption (10^6 lbs.)[a]	Elasticity of Substitution[b]	Decline in Cotton Demand Due to Interfiber Substitution[c] (10^6 lbs.)		
			0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Men's Apparel	1373	-.09	2.101	8.650	22.613
Women's and Girls' Apparel	703	-.18	2.151	8.858	23.157
Home Furnishings	1403	-.20	4.770	19.642	51.350
Industrial Uses	824	-.61	8.545	35.185	91.983
Total	4303		17.567	72.335	189.103

Source: [a]NACC, "Cotton Counts Its Customers, 1969" [9].

[b]USDA Inter-Fiber Study (1974) [12].

[c]Computed by RTI using the estimated price increases from Table VI-9.

ticities and output price increases, i.e., 14.0, 57.3 and 151.1 million pounds. If it is assumed that consumer response to cotton product price increases will be mainly to switch from cotton textile products to manmade fiber textile products, those two alternative estimation methods should provide similar results. Since one cannot be certain which method provides the most accurate results, it was decided to choose the higher figures for the contraction of cotton yarn consumption, namely 17.6, 72.3 and 189.1 million pounds for the three exposure limits, to thus insure that the magnitude of the impact will not be understated. These figures imply that compliance with the OSHA limits of 0.5, 0.2 and 0.1 mg/m^3 will result in the contraction of cotton yarn consumption by 0.41, 1.68 and 4.39 percent, based on the 1967 consumption levels in the absence of exposure limits.

Similar computations were performed on 1972 cotton consumption data by major end-use groups and reported as shown in Table VI-16. Based on these data, the total contraction of cotton yarn consumption due to the OSHA exposure limits of 0.5, 0.2 and 0.1 mg/m^3 are 14.2 million pounds (0.39 percent of the 1972 mill cotton consumption of 3655.2 million pounds), 58.3 million pounds (1.60 percent), and 152.5 million pounds (4.17 percent), respectively.

3) *Reduction of Employment*

In order to assess the employment impact of the OSHA cotton dust exposure limits, it is necessary to identify textile workers who will be directly influenced by the contraction of cotton yarn consumption. It is conceivable that workers in textile finishing, knitting or apparel plants will also be influenced by the contraction of cotton yarn consumption. However, influences on these workers will involve mainly some dislocation within the same industry sector because most of these plants produce both cotton and manmade fiber products. The major impact

Table VI-16. Demand Effects of Interfiber Substitution at 1972 Levels of Output

End-Use Group	1972 Cotton Consumption[a] (10^6 lbs.)	Decline in Cotton Demand Due to Interfiber Substitution[b] (10^6 lbs.)		
		0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Men's Apparel	1117.9	1.710	7.043	18.412
Women's and Girls' Apparel	602.4	1.843	7.590	19.843
Home Furnishings	1356.5	4.612	18.991	49.648
Industrial Uses	578.4	5,998	24.698	64.567
Total	3655.2	14.163	58.322	152.47

Sources: [a]NACC "Cotton Counts Its Customers, 1975" [9].

[b]Computed by RTI using the elasticities of substitution shown in Table VI-15 and the estimated price increases from Table VI-9.

upon employment will be in the yarn spinning and weaving sectors. All the SIC sectors studied (except SIC 2211) include plants which do not specialize in cotton products. Therefore, it is difficult to derive the employment-output relation directly related to the cotton yarn consumption level from the data on these sectors.

SIC Code 2211 (Weaving Mills, Cotton) had total employment of 121,300 and total raw cotton consumption of 2027.6 million pounds in 1972 (see Tables VI-1a, and C-1), indicating that 59.8 employees per year in this industry in yarn spinning and weaving processes will be directly affected by a contraction of one million pounds in the annual consumption of cotton yarn, ignoring process losses between raw cotton and cotton yarn. Similar information derived for SIC 2281 (Yarn Mills, Except Wool)[13] indicates that only 34.4 employees will be affected in the cotton yarn spinning process by a contraction of one million pounds in annual cotton yarn consumption. Total employment of 34,000 persons in SIC 2281, who specialized in cotton yarn spinning, was obtained from Table 5A of *Census of Manufacturers 1972*. This represents 38.2 percent of total employment in SIC Code 2281. Dividing this employment number by raw cotton consumption in SIC Code 2281 (987.6 million pounds), resulted in the 34.4 employees per one million pounds of cotton. The difference between the above two figures in SIC Codes 2211 and 2281 indicates that approximately 25.4 employees will be affected in the weaving process only due to a contraction of annual cotton yarn production of one million pounds.

When this labor/output ratio was applied (59.8 employees/million pounds of cotton yarn) to the contraction of cotton yarn consumption expected at the 1972 level of output, 14.2, 58.3 and 152.5 million pounds, the implication is that OSHA cotton dust exposure limits of 0.5, 0.2 and 0.1 mg/m^3 will result in a reduction of

employment by 850, 3487 and 9120 employees, respectively, for the cotton yarn spinning and weaving processes. These employment reductions may then be subtracted from the additional manpower required by the three exposure limits (393, 776, and 1049, respectively) (see Table VI-1a). The final result implies that employment in this part of the textile industry will be reduced by 457, 2711 and 8071 persons at the exposure limits of 0.5, 0.2 and 0.1 mg/m^3. These figures are 0.1, 0.6 and 1.8 percent of the 1972 total employment (450,400), respectively, in the six SIC sectors studied. However, it should be mentioned that the labor/output ratio, 59.8 employees/10^6 pounds, is biased upward to the extent cotton weaving mills consume yarns obtained from yarn spinners. Consequently, the employment impact may be biased upward, but this bias should not be substantial.

The employment impact of the proposed standards at the 1976 level of output will be less or similar to the above figures because the projected mill consumption of raw cotton for 1976 is substantially lower than the consumption level in 1972 (see Table VI-6). Therefore, the above result can be interpreted as meaning that the cotton dust exposure limits imposed on the 1976 level of output will reduce employment in this part of the textile industry at most by 0.1, 0.6 and 1.8 percent of the 1976 total employment, respectively, in the six SIC sectors.

Table VI-17 details the employment impact of proposed cotton dust exposure limits by SIC sector. Total reductions of employment are distributed to each of the six SIC sectors according to the share of raw cotton consumption out of total raw cotton consumption by the six SIC sectors.

As would be expected, SIC Code 2211 (Weaving Mills, Cotton) reveals the most significant reduction of employment, i.e., 0.2, 1.2 and 3.5 percent reduction of cur-

rent employment level for the 0.5, 0.2 and 0.1 mg/m^3 exposure limits, respectively. Approximately 53 percent of total employment reduction due to the proposed limits will fall within SIC Code 2211. While the next important raw cotton consuming SIC sector 2281 (Yarn Mills, Except Wool) reveals large employment reductions (0.1, 0.8 and 2.3 percent for the three exposure limits), all the remaining sectors reveal minor employment impacts except for 0.1 mg/m^3 limit. One should take account of the fact that the estimate of the employment impact for SIC Code 2281 was biased upward because it also includes employment reductions due to weaving processes. The reductions will, in fact, fall on other sectors which purchase cotton yarns from sector 2281. When this is taken into account, it seems clear that even the employment impact on SIC Code 2281 will not be very large, again with exception of 0.1 mg/m^3 limit.

* * * * *

Compliance by the cotton weaving industry with 0.2 and 0.1 mg/m^3 exposure limits will require 19.6 and 55.6 cents per dollar of sales, respectively, in capital costs which are significant. Somewhat surprising is the low capital compliance cost of 0.129 cents per dollar of sales for the 0.5 mg/m^3 exposure limit. These costs are effectively weighted averages of the costs for the individual sectors of the industry, SIC Codes 2211, 2221 and 2241. These costs and those for the individual sectors must be interpreted with care due to yarn purchases by non-integrated firms, but the $1.10 installed cost per sales dollar for SIC 2211 for the 0.1 mg/m^3 exposure limit are noteworthy. The corresponding cost for the 0.2 mg/m^3 limit is also worthy of note, at $0.39 per sales dollar.

* * * * *

Table VI-24 shows computations similar to those detailed above, but they are estimated per dollar of in-

dustry shipments for yarn consuming sectors. The final column of Table VI-24 shows the average price increase per dollar of sales required due to exposure limits on ginning, yarn spinning and yarn processing (weaving). This column is not equal to the sum of columns four and five due to cotton yarn purchases of non-integrated producers.

The price increases required for SIC Code 2211 (Weaving Mills, cotton) are 1.9, 17.8 and 47.0 cents per dollar of sales for the 0.5, 0.2 and 0.1 mg/m^3 exposure limits, respectively. Similarly, 0.4, 3.8 and 10.0 cents in price increases were required for SIC Code 2221 (Weaving Mills, manmade fiber and silk); 0.3, 3.2 and 8.4 cents for SIC Code 2241 (Narrow Fabric Mills); 0.3, 1.2 and 3.0 cents for SIC Code 2284 (Thread Mills); 0.2, 0.9 and 2.3 cents for SIC Code 2257 (Circular Knit Fabric Mills); and 0.1, 0.5 and 1.3 cents for SIC Code 2296 (Tire Cord and Fabric) to comply with the 0.5, 0.2 and 0.1 mg/m^3 exposure limits, respectively. It is particularly noteworthy that the imposition of the 0.1 mg/m^3 exposure limit on SIC Code 2211 (Weaving Mills, cotton) will result in a 47.0 percent price increase of its products.

* * * * *

d. *Impact on Market Structure and Marginal Industries for Cotton Weaving Sector and Cotton Waste and Linters Consuming Sectors*

Due to the lack of necessary financial data for the cotton ginning sector, the discussion of the capital availability problem in this section will be confined to cotton weaving sectors (SIC Codes 2211, 2221 and 2241) and cotton waste and linters consuming sectors (SIC Codes 2293, 2294, and 2515).

The ratios of capital requirements to profits after taxes for the three weaving sectors were computed using the

Table VI-24 Price Increases of Cotton Yarn Due to Exposure Limits on Ginning, Yarn Spinning and Yarn Processing ($/Dollar of Sales).

SIC Code	Value of Industry Shipments (10^6)	Total Quantity of Cotton Yarn Consumed (10^6 lbs.)	Exposure Limit mg/m^3	Price Increase due to Exposure Limit on Yarn Spinning ($/Dollar of Sales)	Additional Price Increase due to Exposure Limit on Ginning and Yarn Processing ($/Dollar of Sales)[a]	Price Increases due to Exposure Limit on Ginning, Yarn Spinning and Yarn Processing[b] ($/Dollar of Sales)
2211	2660.6	2227.2				
			0.5	.0155	.0022	.0190
			0.2	.0625	.1090	.1776
			0.1	.1644	.2893	.4701
2221	3856.3	694.1				
			0.5	.0038	.0005	.0041
			0.2	.0149	.0234	.0332
			0.1	.0389	.0622	.1011
2241	566.2	85.0				
			0.5	NA	.0004	.0034
			0.2	NA	.0195	.0319
			0.1	NA	.0513	.0843
2257	2008.8	215.7				
			0.5	.0006	.0001	.0020
			0.2	.0022	.0011	.0092
			0.1	.0056	.0012	.0233
2284	345.4	33.9				
			0.5	.0025	.0001	.0025
			0.2	.0106	.0013	.0118
			0.1	.0283	.0016	.0297
2296	685.1	41.0				
			0.5	.0013	.0001	.0013
			0.2	.0048	.0008	.0054
			0.1	.0119	.0010	.0127

[a] Values are the product of the additional price increase per pound due to exposure limits on ginning and yarn processing (from the third column of Table VI-23) and the quantity of cotton yarn consumed (column three of this table) divided by the value of industry shipments (column two of this table).

[b] Values are the product of the coefficients in the final column of Table VI-23 and the third column of this table, divided by the value of industry shipments (column two of this table).

Source: Value of Industry Shipments - Tables C-2, C-7, and C-30. Total Quantity of Cotton Yarn Consumed - Table C-28. Price Increase due to Exposure Limits on Yarn Spinning - Table VI-8.

compliance costs data contained in Table VI-26 and the price increase estimates from the final column of Table VI-24.

Table VI-27 clearly demonstrates that, except at the 0.5 mg/m³ exposure limit, the cotton weaving sectors (SIC Codes 2211, 2221, and 2241), will face difficult capital problems, as measured by the ratio of compliance costs to profits after taxes. For the sector most heavily impacted at the 0.1 mg/m³ exposure limits, namely SIC 2211 (Weaving Mills, Cotton), compliance capital expenditures for all size classes average 2910 percent of annual profits after taxes as compared to 1204 percent for SIC Code 2221 and 787 percent for SIC Code 2241. Further, for the fourth size class (firms with annual sales between $100,000 and $500,000) in SIC Code 2211, this ratio of costs to profits jumps to 66.29, implying expenditures of 6629 percent of after-tax profits. The lowest ratio for this sector at the 0.1 mg/m³ level is 21.00. For Sector 2221, the comparable ratios range from 7.05 to 46.96 for the 0.1 mg/m³ exposure limit, and SIC Code 2241 shows a range between 4.24 and 46.14 for the size classes with positive profits.

Although the ratios at the 0.2 mg/m³ exposure limit for each sector are significantly smaller for all size classes than at the 0.1 mg/m³ exposure limit, the implied expenditure levels are still substantial for SIC Code 2211 (Weaving Mills, Cotton). Ratios for SIC 2211 range from 10.02 to 49.83 and are approximately one half the 0.1 mg/m³ level for this sector. SIC Code 2221 faces the next highest compliance cost requirements at the 0.2 mg/m³ exposure limit, with ratios from between 2.67 to 23.45. The comparable range for SIC Code 2241 is 1.49 to 16.25.

Compliance cost expenditures in the cotton weaving sector fall to less than unity for nearly all size classes

Table VI-26. Installed and Annualized Compliance Costs Per Dollar of Sales ($/Dollar of Sales) Due to Exposure Limits on Cotton Ginning, Yarn Spinning and Yarn Processing: Three Cotton Weaving Sectors.

SIC Code	Exposure Limits mg/m^3	Installed Costs			Total Annualized Costs		
		Due to Yarn Spinning[a]	Due to Weaving[b]	Total	Due to Yarn Spinning[a]	Due to Ginning & Weaving[c]	Total
2211							
	0.5	.0419	.0025	.0444	.0122	.0022	.0144
	0.2	.1943	.3865	.5808	.0477	.1090	.1567
	0.1	.5525	1.0968	1.6493	.1225	.2893	.4118
2221							
	0.5	.0099	.0006	.0105	.0029	.0005	.0034
	0.2	.0459	.0831	.1290	.0113	.0234	.0347
	0.1	.1305	.2358	.3663	.0289	.0622	.0911
2241							
	0.5	.0	.0005	.0005	NA	.0004	.0034[d]
	0.2	.0	.0693	.0693	NA	.0195	.0319[d]
	0.1	.0	.1967	.1967	NA	.0519	.0843[d]

[a] From Table VI-5.

[b] From Installed Compliance Costs for Weaving Sectors in Table VI-22

[c] From the 5th column of Table VI-24

[d] Total annualized costs for SIC Code 2241 were assumed to be equal to price increases required as shown in the final column of Table VI-24

Table VI-27. Ratios of Compliance Cost to Profit After Taxes: Cotton Weaving Sectors.

Annual Sales	SIC 2211			SIC 2221			SIC 2241		
	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3	0.5 mg/m^3	0.2 mg/m^3	0.1 mg/m^3
Average, All Companies	1.610	15.97	29.10	0.410	4.80	12.04	0.0200	2.77	7.87
Under $25,000	-0.037	-0.49	-1.45	-0.009	-0.11	- 0.31	-0.0004	-0.06	- 0.16
$ 25,000 - $ 50,000	-3.170	130.76	35.30	-0.570	-8.47	-46.47	-0.0300	-3.61	-10.25
50,000 - 100,000	-1.450	-53.40	47.79	-0.300	-4.03	-15.20	-0.0100	-1.91	- 5.43
100,000 - 500,000	7.540	49.83	66.29	2.330	23.45	46.96	0.1200	16.25	46.14
500,000 - 1,000,000	2.490	20.82	32.39	0.680	7.51	17.30	0.0300	4.61	13.10
1,000,000 - 5,000,000	2.080	19.26	32.67	0.550	6.23	15.12	0.300	3.69	10.46
5,000,000 - 10,000,000	1.970	18.80	32.91	0.510	5.88	14.48	0.0200	3.45	9.76
10,000,000 - 50,000,000	1.620	16.09	29.37	0.420	4.82	12.10	0.0200	2.78	7.90
50,000,000 - 100,000,000	1.470	14.89	27.79	0.380	4.37	11.08	0.0200	2.51	7.12
100,000,000 - 250,000,000	1.440	14.60	27.27	0.370	4.28	10.86	0.0200	2.46	6.98
250,000,000 - 500,000,000	1.110	11.77	23.37	0.280	3.27	8.48	0.0100	1.85	5.25
500,000,000 - 1,000,000,000	1.550	15.31	27.87	0.400	4.60	11.54	0.0200	2.66	7.55
Over $1,000,000,000	0.910	10.02	21.00	0.220	2.67	7.05	0.0100	1.45	4.24

Source: Calculations are based on data in Tables VI-10, VI-23 and VI-26.

in two of the three SIC Codes (2221 and 2241) if the exposure limit is 0.5 mg/m³. For the remaining SIC Code 2211, capital requirements range from 91 to 754 percent of annual after-tax profits. The comparable range of ratios for SIC Code 2221 is 0.22 to 2.33 and 0.01 to 0.12 for SIC Code 2241.

The ratios for the three smallest size firms are quite volatile and are not particularly meaningful since small changes in costs, prices and profits for such small firms can cause very large changes in the ratios of compliance costs to profits after taxes. Most ratios for all firms with $100,000 or less annual sales are negative for all three exposure limits. But exceptions can occur, such as the second smallest firm size for SIC 2211, where the ratio changed from –3.17 to 130.76 as the exposure limit changed from 0.5 to 0.2 mg/m³. This resulted from an increase in price.

The evidence provided by Table VI-27 is clear. Even though the ability of firms in the cotton weaving sector to finance the burden of compliance costs internally generally increased as firm size increased, it is doubtful whether any firms could successfully finance the cost burden imposed by the 0.1 mg/m³ exposure limits from internal funds. The financial impact for SIC Code 2211 appears very high even for the 0.2 mg/m³ exposure limit. The 0.5 mg/m³ exposure limit would impact much less severely and the cost burden of compliance should be manageable for all but the three smallest firm sizes and possibly selected firms, especially in SIC Code 2211.

* * * * *

6) *Effect on Employment*

The employment impact of the proposed exposure limits upon the cotton textile industry is summarized in Table VI-38. The net reduction in employment will be small for the 0.5 mg/m³ exposure limit, but it will be 7275

and 22,256 persons of the 0.2 and 0.1 mg/m³ exposure limits, respectively. These represent 1.4 and 4.4 percent of the 1972 total employment (511,644 persons) in the ginning, yarn spinning and weaving sectors studied. The total employment reduction for the 0.1 mg/m³ limit (22,256 persons) accounts for .12 percent of the 1972 total employment in all U.S. manufacturing industries (19,028,700 employees). The employment reductions due to the 0.2 and 0.1 mg/m³ exposure limits were estimated by RTI to be 2711 and 8072 persons or .6 and 1.8 percent of current employment level when the limit is imposed on the yarn spinning process alone. Within the cotton textile industry, SIC Code 2211 (Weaving Mills, Cotton) revealed net employment reductions of 4901 and 13,458 persons or 4.0 and 11.1 percent of the current employment level (121,300 employees) for the exposure limits of 0.2 and 0.1 mg/m³, respectively, with limits imposed on cotton ginning, yarn spinning and weaving sectors.

7) *Effects on Market Structure*

The financial impact of cotton dust exposure limits, as measured by the ratio of compliance costs to profits after tax, is summarized in Table VI-39. The exposure limit of 0.1 mg/m³ in SIC Code 2211 (Weaving Mills, Cotton) exhibits extremely high ratios, ranging from 21.0 for the largest firms to 32.9 for smaller firms, ignoring the four smallest size classes. These ratios suggest that it will be very difficult for weaving firms specializing in cotton to finance compliance capital costs imposed by the 0.1 mg/m³ exposure limit. The impact of the 0.2 mg/m³ limit upon SIC Code 2211 is also quite severe, with ratios ranging from 10.0 to 20.8. These ratios indicate that unless the compliance capital investments are spread over a substantial number of years, all the companies engaged heavily in cotton yarn spinning and weaving processes will face severe difficulty in financing compliance capital for both the 0.2 and 0.1 mg/m³ exposure limits.

Table VI-38. Net Reduction in Employment Due to the Proposed Cotton Dust Exposure Limits: Three Major Sectors and Total Industry

SIC or Industry Sector	Exposure Limits mg/m3	1972 Total Employment	Net Reduction in Employment Due to Exposure Limits on Yarn Spinning Process Only		Net Reduction in Employment Due to Exposure Limits on Cotton Ginning, Yarn Spinning and Weaving Sectors	
			Number of Employees	Percent of the 1972 Employment Level	Number of Employees	Percent of the 1972 Employment Level
2211		121,300				
(Weaving Mills,	0.5		242	.2	386	.3
Cotton)	0.2		1,435	1.2	4,901	4.0
	0.1		4,269	3.5	13,459	11.1
2221		149,700				
(Weaving Mills,	0.5		83	.1	122	.1
manmade fiber and	0.2		491	.3	1,598	1.1
silk)	0.1		1,461	1.0	4,398	2.9
2281		89,700				
(Yarn Mills,	0.5		117	.1	41	.04
except wool)	0.2		699	.8	1,132	1.3
	0.1		2,080	2.3	3,255	3.6
Total of Yarn		450,400				
Spinning Sectors	0.5		457	.1		
(SIC Codes 2211,	0.2		2,711	.6		
2221, 2281, 2257,	0.1		8,072	1.8		
2284 and 2296)						
Total of Cotton		511,644				
Ginning, Yarn Spinning,	0.5				578	.1
and Weaving.	0.2				7,275	1.4
	0.1				22,256	4.4

Sources: Tables VI-17 and VI-33.

As shown in Tables VI-11 and VI-27, the ratios generally decline as company size increases, i.e., the ratios are larger for small size classes than for larger size classes. Also, the difference in the size of ratios between classes is quite pronounced, suggesting that the difficulty of financing the compliance capital costs will be more intense for smaller companies. Therefore, it is undeniable that the proposed cotton dust exposure limits of 0.2 and 0.1 mg/m^3 could impose some degree of limitation on market entry and increase concentration in the cotton yarn spinning and weaving sectors. However, the results in this analysis only point out the relative difficulties among size classes of companies and industry sectors. Because of severe data problems (lack of detailed financial data at the company level), it fails to identify specifically which plants will close or what proportion of total production capacity will be eliminated due to compliance capital requirements.

* * * * *

2) *Cotton System Machinery in Place*

a) *General*

For other than spinning frames, data were not available that would permit breaking down cotton system equipment by type of fiber processed, i.e., 100 percent cotton, 100 percent man-made, and cotton-man-made blends. For the purposes of the equipment inventory, it is assumed that other cotton system equipment will be distributed by fiber processed in the same ratio as spinning spindles. In 1973 the American Textile Manufacturers Institute reports the following distribution of spinning spindles by fiber processed [16]:

Fiber	*Percent Active*
100 percent cotton	55.1
100 percent man-made	13.4
other fibers and blends	31.5

Table VI-39. Ranges of Ratios of Compliance Capital Costs to Profit After Tax: Three Major Sectors

SIC	Exposure limits mg/m^3	Ranges of Ratios of Compliance Capital Costs to Profit After Tax[a]	
		When the limits are imposed on yarn spinning only	When the limits are imposed on ginning, yarn spinning and weaving
2211 (Weaving Mills, cotton)	0.5	.9 - 2.5	.9 - 2.5
	0.2	3.6 - 9.1	10.0 - 20.8
	0.1	8.0 - 13.5	21.0 - 32.9
2221 (Weaving Mills, manmade fiber and silk)	0.5	.2 - .6	.2 - .7
	0.2	1.0 - 2.7	2.7 - 7.5
	0.1	2.5 - 6.2	7.0 - 17.3
2281 (Yarn Mills, except wool)	0.5	.5 - 1.5	
	0.2	2.2 - 5.5	
	0.1	5.3 - 10.6	

[a] Ranges of ratios exclude those for the four smallest size classes. As may be noted in Table VI-10, the three smallest size classes reveal negative profits after taxes. The fourth smallest size class shows positive profit after tax but its value is extremely small compared with other larger size classes.

Sources: Table VI-11 and VI-27.

Table B-11. Costs Per Cubic Foot Per Minute of Air for Processing Equipment*

Equipment Type	1.0 mg/m^3				0.5 mg/m^3				0.2 mg/m^3			
	Air Required (CFM)	Capital Costs ($/CFM)	Operation & Maintenance ($/CFM/Yr)	Energy Consumed (Kwh/CFM/Yr)	Air Required (CFM)	Capital Costs ($/CFM)	Operation & Maintenance ($/CFM/Yr)	Energy Consumed (Kwh/CFM/Yr)	Air Required (CFM)	Capital Costs ($/CFM)	Operation & Maintenance ($/CFM/Yr)	Energy Consumed (Kwh/CFM/Yr)
Openers (Conventional)	8,000	1.50	.047	7.98	8,000	1.90	.059	12.62	8,600	2.89	.060	12.73
Pickers (Conventional)	8,500	1.59	.045	7.98	8,500	2.01	.053	12.62	8,600	2.97	.056	12.73
Openers (Chute)	15,070	1.56	.043	7.98	15,070	1.97	.053	12.62	15,670	2.99	.056	12.73
Cards	996	1.74	.048	11.07	996	2.19	.058	16.91	1,540	3.10	.054	12.73
Draw Frames	1,122	1.78	.030	7.03	1,122	2.24	.037	11.22	1,980	2.24	.034	12.73
Combers	-	-	-	-	-	-	-	-	800	2.18	.023	12.19
Roving Frames	-	-	-	-	1,540	2.43	.023	10.23	3,660	2.34	.029	12.68
Spinning Frames (Ring)	-	-	-	-	2	2.11	.062	11.70	8.75	2.31	.035	11.70
Spinning Frames (Open End)	-	-	-	-	2	2.11	.062	11.70	8.75	2.31	.035	11.70

Source: Research Triangle Institute.

*Air requirements and associated costs for the 0.1 mg/m^3 limit were not calculated. The methodology used for estimating costs at this level employed extrapolation from the control cost function rather than direct cost estimation based on air flow requirements.

Data on cotton system equipment is developed for each of the fiber categories listed above. The most conservative approach in estimating control costs would be to treat all equipment as if it were processing 100 percent cotton. A middle-of-the road approach would be to exclude the equipment processing 100 percent man-made fibers. The most liberal approach would be to consider costs for equipment processing 100 percent cotton and half of that processing blends. In 1973 it was estimated that 76 percent of the cotton used in blends was in 50-50 proportions [17].

The basic source of data on cotton system equipment is the Bureau of the Census special report, *Textile Machinery in Place* [18]. The data in this report are an aggregation of reports from companies representing 90 percent of the employment in the textile fiber and yarn preparation industry. The following nationwide totals are estimated by dividing the Bureau of Census data by 0.9.

* * * * *

4) *Raw Cotton Processed by Equipment Type*

In this section estimates of the average amounts of raw cotton processed per unit of equipment are developed. These data are necessary to transform the control costs, expressed in terms of unit of equipment, to dollars per pound of raw cotton. The latter figure is required for input into the Input-Output model used in evaluating the economic impact of proposed cotton dust exposure limits, in which the throughput of cotton by industry classification forms one basis of the analytical model.

Except for combs and cards, calculations of raw cotton processed per unit of equipment are relatively straight forward and involve dividing the annual raw cotton consumption by the units of equipments in place developed in Section C, above. Distribution of raw cotton to carding systems requires consideration of nominal capacities

of high and low speed cards. Distribution of raw cotton to combing systems requires consideration of the percent of cotton end use requiring combed yarn.

As previously mentioned, economic evaluation can be made using control costs for:

A. All cotton system equipment in place.

B. Cotton system equipment producing 100 percent cotton fiber and cotton blends.

C. Cotton system equipment producing 100 percent cotton fiber and half of the equipment producing cotton blends.

Calculated equivalent raw cotton throughput by types of cotton systems equipment are shown in Table B-14. Details of calculation and basis of distribution are presented in Tables B-15 through B-21. All calculations are based on the 1973 raw cotton consumption of 7,078,000 bales (480 lbs./bale).

Calculations based on all fibers produced (A above) are converted to category B by dividing by 0.866, the percent of all equipment less equipment producing 100 percent man-made fibers; and for category C by dividing by 0.709, the percent of all equipment less equipment producing 100 percent man-made fibers and one-half of the equipment producing cotton blends.

* * * * *

Plant and equipment expenditures in constant 1974 dollars declined sharply in the textile industry from 1948 to 1958 as shown in Table C-12. However, by 1974 the expenditures reached the record high amount of $840 million in current dollars, and according to Department of Commerce forecasts the 1976 spending ($850 million) will exceed 1974 levels. * * * These expenditures are small when compared to the paper industry ($2,533 million)

Table C-11. Cotton System Spindle Activity

Year	Number of Cotton System Spindles (10^6) In Place	Number of Cotton System Spindles (10^6) Active	Spindle Hours Operated (10^9 Hours)	Index of Cotton System Activity (Based on 132 Hours Per Week Per Spindle)
1959	20.274	19.248	122.7	82.8
1960	19.956	19.221	120.1	74.6
1961	19.603	18.986	117.0	72.4
1962	19.491	18.764	118.7	74.5
1963	19.302	18.634	118.1	76.2
1964	19.322	18.472	124.6	80.1
1965	19.332	18.757	128.0	81.7
1966	20.046	19.467	132.1	97.6
1967	20.605	20.041	126.2	90.0
1968	20.513	19.996	128.0	91.0
1969	20.133	19.562	125.6	88.6
1970	19.559	18.599	113.0	83.1
1971	19.215	18.424	113.8	84.3
1972	19.089	18.301	115.8	88.2
1973	18.890	18.036	116.0	89.1
1974	18.606	17.255	106.3	82.2

Source: American Textile Manufacturers Institute, Inc., Textile Hi-Lights, various issues.

Table C-12. Plant and Equipment Expenditures, $ million
(1974 Constant Dollars)

Year	Textiles	Paper	All Manufacturing	Wholesale Price Index of Machinery & Equipment (1967 = 100)
1947	1323.910	960.483	NA	53.7
1948	1389.210	910.170	21580.6	58.2
1949	1051.210	685.573	16270.9	61.0
1950	949.951	729.032	16325.9	63.1
1951	949.105	830.467	21176.9	70.5
1952	789.801	710.821	22608.0	70.6
1953	656.453	791.605	22898.6	72.2
1954	569.754	854.631	21346.8	73.4
1955	570.857	939.153	21895.2	75.7
1956	647.578	1687.11	26244.0	81.8
1957	509.223	1273.06	26272.7	87.6
1958	343.042	888.791	19303.9	89.4
1959	458.049	946.636	19497.6	91.3
1960	560.629	1166.72	22864.6	92.0
1961	500.565	970.793	21736.7	91.9
1962	575.781	1000.04	22819.1	92.0
1963	650.129	1088.59	24523.5	92.2
1964	781.119	1457.09	29051.6	92.8
1965	979.807	1811.16	34798.0	93.9
1966	1180.87	2059.32	40610.3	96.8
1967	947.918	2174.64	39742.9	100.0
1968	715.909	1783.02	38321.4	103.2
1969	824.618	1859.97	41466.5	106.5
1970	700.753	1748.13	39980.4	111.4
1971	736.224	1444.69	36195.7	115.5
1972	863.120	1561.89	37056.9	117.9
1973	881.937	2037.73	43538.1	121.7
1974	839.999	2533.00	45689.9	139.4

Sources: ATMI, Survey of Current Business and Textile Hi-Lights

in 1974 and to the all-manufacturing average ($45,690 million) for the same year. * * * This decline in textile plant and equipment expenditures as compared to similar activity in all manufacturing and the paper industry suggests that perhaps this investment profile can, in part, be explained by declining or stagnant profit margins.

* * * * *

6. *Profitability*

Net profit per dollar of sales in the textile industry is somewhat cyclical but has typically ranged from about 2 cents to 3 cents since the mid-1950's (3 cents to 8 cents from the mid-1940's to the mid-1950's). As shown in Table C-17, the paper industry typically earned 4 to 8 cents per dollar of sales over the 1947-74 period. The pattern for all manufacturing was similar to that of textiles except the level of net profits per sales dollar was about twice that of textiles. Cash available for investment per dollar of sales for the textile industry and for all manufacturing has been in the 4 to 5.5 cents range since the early 1960's.

As shown in Table C-18, total assets per dollar of sales in the textile industry has averaged 60-70 cents since the mid-1950's, but the recent trend is downward. The rate of return to investment for textile firms as a whole improved relative to all manufacturing firms from 1969-74, and while the rate of return to investment in textiles has historically been low, in the 2-3 percent range, it rose to approximately 4 percent after 1971.

* * * * *

8. *Fiber Consumption*

Cotton's share of the total domestic fiber market has declined consistently from the 1947-52 average of about 70 percent to 29.5 percent of the market in 1974. Cotton's market share remained above 50 percent until 1967, as shown in Table C-20, after which it dropped rapidly. The decline in mill consumption of cotton in the U.S. was

due primarily to the development of synthetic fibers and yarns, and in particular the development of textured yarns. Fabrics made from some synthetic fibers have historically possessed attractive properties such as superior wear and easy-care properties, but many of these fabrics were smooth and slippery to the touch and felt clammy when worn next to the skin. They often did not possess the warmth and comfort of fabrics made from cotton and other natural fibers. Synthetic yarns spun from staple afforded some of the advantages of cotton, and helped alleviate some of the disadvantages of filament yarns, but not all of them. Textured yarns followed.

Fabrics made from textured yarns have greater bulk, drier hand, high covering power, increased comfort, increased moisture absorption, improved thermal insulation, and more subdued luster when compared to fabrics made from continuous filament yarns. When compared to fabrics made from spun staple of equivalent denier *, fabrics made from textured yarns have (typically) equal or lower bulk density, a drier and crisper handle, a significantly improved freedom from pilling, and much greater uniformity. These properties substantially improve the quality of the fabric and add to consumer satisfaction. In addition, blends of cotton and synthetics, primarily nylon and polyester, have cut substantially into the market for cotton. In 1974, consumption of man-made fiber at the mill level constituted almost 70 percent of the market.

* * * * *

As shown in Tables C-21 and C-22, increasing import trade balances of cotton correspond to the decline of cotton's share of total mill consumption. The net cotton export balance dropped sharply during the 1950's and was reversed to a net import trade balance in 1960. The figures in the last column of Table C-21 represent the

* A unit of fineness for silk, rayon or nylon yarn equal to the fineness of yarn weighing one gram for each 9,000 meters.

share of domestic raw cotton out of total domestic consumption of cotton. The ratio has dropped consistently from 1.11 in 1948 to 0.97 in 1974. This implies that more than 8 percent of domestic cotton consumption was provided (on net) by foreign suppliers in 1974. (Domestic cotton consumption is the mill cotton consumption adjusted for imports and exports of cotton.)

* * * * *

9. *Interfiber Competition*

Cotton and man-made fibers compete for markets on the basis of both price and non-price factors. A USDA study[2] notes that non-price factors have probably dominated in the past. As examples of non-price factors, the USDA study lists the following: new man-made fibers with characteristics appealing to consumers, or with specific properties applicable to industrial use; large expenditures on research, development and promotion by man-made fiber industries; and the availability and quality of supply. Prior to the energy shortage, mills were generally assured of a predictable supply of man-made fiber of a constant quality and at relatively stable, predictable prices. Wholesale fiber prices and the price of man-made fibers relative to cotton are given in Table C-23.[*] Production and quality of cotton are less dependable. Such factors as weather, insects, and government programs, none of which can be predicted with certainty, affect quality, quantity, and prices of cotton[2].

At this point, a short discussion of technical difficulties of interfiber substitution is relevant. In order for cotton and man-made fiber to compete directly on the basis of price, shifts back and forth between them must be easily made at all levels between producer and consumer. The USDA study points out that ". . . at the mill level, it is difficult and time-consuming to change from production of 100 percent man-made fiber to production of 100 percent cotton fiber, or vice versa. Major difficulties may

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[* This table omitted in printing.]

even be encountered in shifting from production of man-made fiber-cotton blends to production of 100 percent cotton fabrics. All of one fiber must be run out of the machines which are changing fiber and the machines must be thoroughly cleaned. This is a major undertaking and, naturally, quite time-consuming. During the change, neither labor nor machines operate at peak efficiency. So, once a mill shifts from cotton to man-made fiber in response to an anticipated price or supply movement, it is unlikely that the change will be reversed unless planners at the individual mill level feel they must do so to avert a severe profit squeeze or to respond to strong consumer demand. This explains in part the difficulty cotton experiences when attempting to recover markets in a specific end-use once it has been displaced.

In this study, the inter-fiber competition based on price factors is analyzed only at the end-use level because, as shown in the USDA study cited above, the cross-price elasticities of cotton vary significantly among the major end-users. The distribution of cotton consumption by major end-users is shown in Table C-24. The end-use data are published by Textiles Economic Bureau, Inc.[3].

Home furnishings is the largest end-use of cotton of the four markets, followed by men's and boys' apparel. In 1973, 36 and 32 percent of all cotton were used in home furnishings and men's and boys' apparel, respectively. Within the home furnishings category, the largest use of cotton is sheets, where four-fifths of the fiber used is cotton. In the other major end-use product, towels, cotton accounts for 98 percent of the fiber used.

The USDA study also indicates that a 10 percent increase in the cotton/non-cellulosic price relationship

Table C-24. Distribution of Cotton Consumption by Major End-Uses for 1972, 1973, and 1974.

	1972		1973		1974	
	Quantity (10^6 lbs)	Percent	Quantity (10^6 lbs)	Percent	Quantity (10^6 lbs)	Percent
Men's and Boy's Apparel	1117.9	30.6	1085.8	32.0	1044.0	33.5
Women's, Misses, Children's and Infants' Apparel	602.4	16.5	522.2	15.4	478.1	15.4
Home Furnishings	1356.5	37.1	1232.6	36.3	1103.0	35.4
Industrial Uses	578.4	15.8	556.3	16.4	486.7	15.6
Total	3655.2		3397.4		3112.3	

Source: National Cotton Council of America, Cotton Counts Its Customers

elicits the following percentage declines in cotton demand by each major end-user:

Men's Apparel:	0.9 percent
Women's Apparel:	1.8 percent
Home Furnishings:	2.0 percent
Industrial Uses:	6.1 percent

The above estimations are based on the observation that much of the displacement of cotton occurred as non-cellulosics became more price-competitive with cotton.

The cross-price elasticities of cotton in men's wear is the lowest (and statistically insignificant) among the four major end-users. The USDA explains that this is not particularly surprising because over half of this market is in utility-type clothing and underwear. Prices would be a minor consideration affecting demand, as these products are relatively low priced; non-price factors seem to dominate. For example, cotton reportedly wears better than blends or man-made fibers in work clothes and men's underwear. The industrial users reveal the highest cross-price elasticity among the four end-users. Uses in this category include sewing thread, cordage, coated fabrics such as parachutes and transportation upholstery. Man-made fiber penetration has caused cotton's share of the market to fall from over half in the early 1950's to less than one-third by the early 1970's. Much cotton has been displaced in end-uses such as cordage. But it is important to note that the high historical estimate of cross-price elasticity should be used with caution because this relatively high elasticity may indicate only that most potential cotton displacement has already transpired[2].

In the USDA's regression equation, the total fiber demand variable in each major end-user group was included as a proxy variable for all macro-demand shifters af-

fecting individual fibers, such as income, technological advances, and changing tastes and preferences. Therefore, the estimates of cross-price elasticity portray the competitive relationships between cotton and non-cellulosics for a given level of total fiber demand. In the impact analysis, it was assumed that all macro-demand shifters remain constant for a given year. Therefore, these elasticity estimates are suitable for our purpose. The reduction of cotton demand due to inter-fiber substitution can be added to the reduction of cotton consumption due to the decrease of final demand for textile consumer products resulting from the output price increase.

10. *Foreign Trade*

During 1961, the U.S. requested that the nations of the General Agreement on Tariffs and Trade (GATT) convene and seek solutions to what were publicised as growing international problems in the trade of textiles and apparel products. The immediate results of the 1961 GATT meeting was the Short Term Arrangement Regarding International Trade in Cotton Textiles (STA), which was a temporary measure lasting one year, until October 1, 1962, when the Long Term Arrangement Regarding International Trade in Cotton Textile (LTA) came into effect. Both of these agreements relate only to cotton and apparel products composed of 100% cotton or chief-fiber or chief-value blends of cotton (over 50% cotton by weight or value, respectively). Under both of these agreements the U.S. imposed 5 percent quotas on the annual growth rate of cotton textile and apparel imports using the vehicle of bilateral agreements, mostly with nations outside the industrial Western world. The LTA was renewed twice and expired on December 31, 1973.

Under the general terms of the LTA, international trade of these products was limited only when the ex-

ports caused disruptive effects on the markets of the importing nations. Market disruptions, relative to textiles and as discussed by GATT, were situations which contained the following elements, most probably in combination: a) serious damage to domestic producers of textile and apparel products (or the threat of serious damage) from imports of these products from a particular source; any such damage or potential damage had to result directly from market disruption and not from technological change, change in consumer tastes and preferences or changes in other factors causing shifts in supply and/or demand; b) sharp and substantial increase or potential increases of imports of textile and apparel products from particular nations or sources; c) these products offered at substantially lower prices than the prevailing domestic market price for similar goods of comparable quality in the importing country.

In the U.S. in late 1961, depreciation allowances were liberalized for investment in textile machinery, equipment and other capital items, and provided considerable incentive for new investment in the U.S. textile industry. Specific tax provisions reduced the average tax-life of textile mill equipment from 25 to 14 years, except for finishing equipment which was reduced to twelve years. Currently, the U.S. government is developing new depreciation schedules for textile capital, presumably for use in 1976.

When the tax incentives were combined with the import protection provided by the STA and LTA and amplified by the fairly rapid 5 percent average annual rate of growth of real U.S. domestic textile demand during most of the 1960's, investment in the U.S. textile industry expanded very rapidly. Expenditures on new plant and equipment in the textile mill sector increased in constant (1974) dollars from the $500 million in 1961 to $1,181 million in 1966, dropped to $948 million in

1967, $716 million in 1968, and rose to about $825 million in 1969. From about $700 million in 1970, there was an increase to $882 million in 1973 and a drop to $840 million in 1974 and to $660 million in 1975. Some of the expenditures on plant and equipment in the early 1970's in the U.S. textile industry were stimulated by increased export demand resulting from international monetary adjustments.

Domestic demand for textile products declined in the U.S. in the late 1960's, but the gradual increase in total imports of manmade fiber products that existed throughout most of the 1960's increased sharply in the late 1960's. By 1970 over $1.94 billion of foreign textile manufacturers reached U.S. markets. Of this import figure, about $1.05 billion was attributable to manmade fiber products, about $536 million was cotton products, and $358 million was wool products. In 1971 imports of manmade fiber products into the U.S. increased 50 percent over the 1970 figure to over $1.55 billion, as compared to $590 million for cotton products, $292 million for wool products, $2.435 billion for the total imports of textile manufactures, and $2.9 billion for total textile imports.

Textile manufactures, as discussed here, are essentially manufactured textile products and are a good measure of the foreign trade activity most central to the industries of interest in this study, namely SIC Codes 2211, 2221, and 2281. In this sense, textile manufactures consist of yarns, broadwoven fabrics, woven and knitted apparel, make-up goods (pillow cases, dish towels, other towels, table cloths, sheets, bedspreads, quilts, etc.), and miscellaneous items not classified elsewhere (woven elastic, fishing nets, etc.) See Tables C-25, C-26 and C-27 for additional data.

Given these data, it is clear that the LTA, with its singular emphasis upon cotton and cotton blends, was

inadequate to control the growth rate of textile and apparel imports into the U.S. As a consequence, in 1971 President Nixon's Administration led the negotiation of new bilateral trade agreements with five countries (Japan, Taiwan, Hong Kong, South Korea, and Malaysia) covering exports to the U.S. wool and man-made fiber textiles and apparel, in addition to cotton textile and apparel products covered under the LTA. These agreements imposed trade limitations upon some eighteen classifications of textile and apparel products from Japan, covering some 50 percent of Japanese exports of wool and manmade fiber products to the U.S., and ten categories, covering about 80 percent of their U.S. exports, for the other countries. These became effective on October 1, 1971. Under the terms of these agreements, Japan agreed to limit the rate of growth of exports of these classifications of textile and apparel products to the U.S. to 5 percent per year for man-made and one percent for woolen products for three years, while the other agreements were for five years and limited the rate of growth of exports of these products to the U.S. to approximately 7.5 percent per year. In 1973, additional agreements were negotiated with Singapore and Macao.

These agreements were neither a comprehensive nor a long-run solution, and a more general international framework was sought. In the Multi-lateral Trade Negotiations in Geneva, which dealt with all international trade activities (including textiles and apparel), and in other negotiations, GATT developed the Arrangement Regarding International Trade in Textiles or the Multi-Fiber Arrangement Regarding International Trade in Textiles (MFA), which was accepted by the U.S. and became effective on January 1, 1974. Under the MFA, the U.S. negotiated bilateral agreements with some sixteen countries covering cotton, wool and manmade fiber products. The terms of each of these agreements differ some-

what, but the rate of growth of exports from these countries to the U.S. typically is in the six to seven percent range for included products.

The international monetary changes since August of 1971 have had a significant effect upon foreign trade of U.S. textile products, which have become more competitive in world markets. Total textile exports increased from $837 million in 1971 to $993 million in 1972, $1.5 billion in 1973, $2.16 billion in 1974 and dropped slightly to $2.03 billion in 1975. During the same time period, exports of textile cotton manufactures increased from 694.8 million equivalent square yards in 1971 to 1.215 billion square yards in 1974, dropping to 1.046 billion yards in 1975; all major components of cotton textile manufactures showed increases, the smallest absolute and percentage increase being cotton yarns.

Imports of textile manufactures levelled off in the 1972-75 period in the $2.85 to $3.2 billion range, due to monetary adjustments, the trade agreements of 1971, and the Multi-Fiber Agreement. The People's Republic of China, not currently participating in a limiting trade agreement with the U.S., increased exports to the U.S. from about 85 million square yards equivalent (SYE) in 1974 to about 139 million SYE in 1975, mostly in the woven cotton fabric market.

Large changes in the relative prices of domestic and foreign textile and apparel products do have an impact upon the domestic textile industry; the dollar devaluations caused observable export response. However, small price changes have had very little impact, and, in general, the trade agreements dampen the effects on domestic markets of small changes in relative prices.

EXHIBIT 11

Statement of Dr. Arend Bouhuys

Byssinosis—in its acute as well as its chronic stages—is a significant hazard to health among workers exposed to cotton dust. Conservative estimates are that at least some 17,000 workers in the cotton fiber processing industry were at risk of the acute effects of cotton dust exposure in 1969 (Zuskin et al., Arch. Envir. Health, 19: 666, 1969), while there may be at least some 35,000 men and women (of these, 15,000 younger than 65 years of age) with disabling loss of lung function related to their work in the cotton textile industry in the United States (Bouhuys et al., Chronic respiratory disease in cotton textile workers; submitted for publication, 1977). Thus, large numbers of cotton textile workers are either affected by recurrent shortness of breath, chest tightness and other symptoms associated with a temporary effect of cotton dust on the lungs during exposure at work, or have sustained permanent damage to lung function, and concomitant chronic shortness of breath and other symptoms as a result of long-standing exposure to dust in cotton textile mills. Among the latter, many retire prematurely because of chest symptoms and respiratory disability (e.g. Bouhuys et al., New Engl. J. Med., 277: 170, 1967).

* * * * *

(6) I assume that "affected employees" refers to "employees affected by the standard." Considering that some cases of byssinosis have been observed even in workplaces with respirable dust levels less than 200 ug/m^3 (e.g. in Merchant et al.'s studies in North Carolina), and that byssinosis rates from 13 to 26% have been observed in carding and spinning rooms with respirable dust levels around 500 ug/m^3 (data from Bouhuys et al., Ann. Int. Med. 71: 257, 1969, and from Zuskin et al.,

Arch. Envir. Health, 19: 666, 1969), I do not consider that the proposed standards include any clear margin of safety. In fact, it is likely that some workers may continue to be affected by dust exposure, at least during work on Mondays, even when the standard is fully implemented in all cotton textile mills. However, it is likely that the standard is sufficient to avoid severe acute effects of dust exposure in a large majority of workers at risk, and it is also probable that implementation of the standard would greatly decrease the prevalence of disabling chronic lung disease among cotton textile workers in the future. In comparison with margins of safety which are considered in setting standards for other environmental exposures, e.g., those to outdoor air pollutants or to food additives, the proposed standard for cotton dust is considerably less stringent.

(7) The reversible physiological changes induced by cotton dust exposure need to be prevented and should therefore be considered in establishing a standard. The reversible effects of cotton dust exposure on the lungs of workers constitute a recurrent insult to their lungs which is unacceptable if only for the fact that they are associated with symptoms of cough, chest tightness, shortness of breath, and wheezing. In addition, it is likely although not definitely established that recurrent acute effects of dust exposure contribute to the insidious development of chronic lung disease. Finally, there is evidence that the acute effect of hemp dust on lung function may be accompanied by temporary decreases of arterial oxygen partial pressures (Lopez-Martino et al., Am. Rev. Res. Dis., 107: 809, 1973). Similar studies have not been reported for cotton textile workers, but since the acute effects of cotton and hemp dusts on lung function are similar, prudence indicates the assumption that temporary hypoxemia may also result from acute dust exposures to cotton dust. There can be little question that any

exposure which may result in temporary disturbances of the supply of oxygen to the tissues of the human body needs to be prevented.

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Byssinosis has been recognized as an important health hazard to U.S. cotton textile workers since 1967.

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(2) *Relations between byssinosis and chronic bronchitis.* —Some authors have described byssinosis as a form of chronic bronchitis, with some added acute effects due to short-term dust exposure. However, the accepted definition of chronic bronchitis is merly that of a syndrome consisting of chronic cough and sputum production which has persisted over a defined period, usually 3 years. The term "chronic bronchitis" carries no implications about etiology nor does it allow one to distinguish between various causes of that particular symptom complex. To a large extent, the continuing discussion concerning the coexistence of chronic bronchitis and of byssinosis is one of semantics. Cotton and other textile workers are at risk of acute as well as chronic respiratory symptoms and lung function loss. There is little or no doubt that both are caused by exposure to respirable dust in cotton textile factories. Although the progression from repeated acute insults to the chronic disease has not been traced with certainty, there is no good evidence against—and much evidence for—such a train of events. It seems most logical to define byssinosis as a dust-induced disease with initia acute responses followed by a stage of chronic lung disease characterized by chronic airway obstruction. This definition is implicit in the description of the clinical stages of byssinosis given by Schilling many years ago. There is little or no reason to describe cotton textile workers who, as a part of this disease, complain of chronic cough and of chronic sputum production as having some separate disease entity labeled chronic bronchitis.

Rather, it should be understood that the term "chronic bronchitis" is merely a convenient label, which has been useful in epidemiological studies, to describe persons who cough and who produce sputum, whatever the cause may be.

* * * * *

Disabling lung function loss was found among lifelong non-smoking cotton textile workers in South Carolina (4 men, 26 women aged 45 and over). The larger number of disabled non-smoking women reflects the fact that 70% of all women in the textile worker study had never smoked; among the men, this percentage was only 27%. In the same age group, there were 14 male and 10 female smokers and ex-smokers with equally severe function loss ($FEV_{1.0} < 1.20$ liters). These smokers and ex-smokers were, on the average, 5.7 years younger than the disabled non-smokers. This difference in mean age was statistically significant ($p < 0.01$). Hence the additive effects of textile dust exposure and of smoking (see above) appear to decrease the age at which textile workers become disabled. Careful review of the records of all disabled individuals did not reveal any causes of lung function loss other than textile dust exposure and smoking.

The proposed standard document states (p. 56498, col. 3, I. Background, A. General, first paragraph) that at least 800,000 workers were employed in the cotton fiber processing industry in the United States in 1973. Our population includes 302 active workers, 165 retired workers aged 45-64 years, and 178 retired workers 65 years and older. A crude estimate of the impact of disabling byssinosis in the U.S. can be made from these figures. If, of the 800,000 employed, 200,000 are at risk in dusty jobs and aged 45-64 years, there may be at least an additional 225,000 persons (109,000 aged 45-64; 118,000 aged 65+) who are no longer employed in the industry. The prevalence of disabling function loss ($FEV_{1.0} < 1.20$ liters) in our population is 4.9% for all 45-64 year olds,

and 17.4% for the men and women aged 65 years and older. If these percentages reflect average prevalences in U.S. cotton textile workers, one estimates that there may be at least 35,000 men and women with disabling function loss related to their work in the cotton textile industry in the U.S. Of these, about 15,000 would be 64 years or younger.

The above estimate represents, of course, an extrapolation from limited data and should not be considered as anything but a crude estimate. But since we were much more likely to trace active workers (who still lived and worked in the area where we conducted our survey) than retired workers (many of whom moved away or were untraceable) it is unlikely that we overestimate the prevalence of disabling lung function loss among the population of cotton textile workers which we studied. There are at present no other data except those quoted for Spanish hemp workers which might allow an independent estimate. Studies which include retired as well as active workers have not been reported from any country where significant numbers of people are at risk of cotton dust exposure. The one study in Spain suggests that our estimate for the U.S. may, if anything, underestimate the prevalence of disabling lung disease associated with textile dust exposure.

In conclusion, I support the adoption of the proposed standard for cotton dust exposure and urge its implementation on the shortest term feasible. Further delays in preventing an occupational lung disease which has been known since more than 100 years, and which has been documented by several independent investigators in the U.S. during the past ten years, should not be acceptable in our society.

EXHIBIT 13

Statement of Dr. Hans Weill

* * * * *

In spite of limitations in analysis, making it unlikely that a single cotton dust standard would be equally protective in all mills where multiple factors vary considerably, it is suggested that a level of cotton dust exposure which carries an acceptably low risk of byssinosis will fall between 0.2 and 0.5 milligrams per cubic meter.

* * * * *

EXHIBIT 13A

Report to the American Textile Manufacturers' Institute on a Study entitled Assessment of Respiratory Responses in Textile Workers exposed to Low Levels of Cotton Dust

May 31, 1976

Tulane University School of Medicine

Principal Investigator: Hans Weill, M.D.

Co-investigators: Robert Jones, M.D.; John Diem, Ph.D.; Henry Glindmeyer, M.S.M.E.; V. Dharmarajan, Ph.D; Jean Carr, M.S.

I. Introduction

This study was undertaken to detect the presence of and quantitatively assess any adverse respiratory response to occupational exposure to low levels of cotton dust in the textile industry. While an acute bronchoconstrictor response and its clinical equivalent, byssinosis, have long been associated with cotton dust exposure, opinion differs in regard to the dose-response relationships at the lower end of this curve. The practical question concerns the setting of a permissible cotton dust exposure standard which will carry an acceptable risk for the development of byssinosis. This investigation addresses the question of a "safe" cotton dust exposure in regard to clinical and physiologic evidence of an acute bronchoconstrictor response. Biologic effect was measured by questionnaire responses and pulmonary function testing, these determinations being correlated with concurrent measurements of respirable cotton dust in the work place.

Study design was developed to examine the relationship of byssinosis to past levels of dust exposure in the presence of current low level exposure. Mills with similar current low cotton dust levels were selected where there had been different past levels, specifically high, low and

an absence of previous cotton dust exposure in a mill which had converted from non-cotton to cotton processing. It should be emphasized that the selection of the study mills was based on their meeting the criteria of low current dust levels and the described past exposure patterns. These plants undoubtedly represent the best environmental dust control in the industry and are not necessarily representative or typical of industry-wide environmental conditions. A plant having processed only synthetics and wool served as a control. In addition, the effects of smoking and length of cotton dust exposure were examined, particularly in regard to their possible interaction with levels of past and current dust exposure.

II. Research Plan

A. Mills

The study population included employees working in opening through warping in textile mills selected to reflect four types of exposure histories. The mills are identified by Roman numerals I through IV as noted in Table 1. Mill I had been processing cotton for only four years. Mill II had been processing cotton for many years but had only recently achieved satisfactory dust control with resulting concentrations of respirable cotton dust approximating 0.5 milligrams per cubic meter. Mill III consisted of three installations geographically proximate (a, b, c) where dust exposure has been known to be low for approximately ten years. Mill IV has never processed cotton, this mill using only synthetic fibers or wool. All mill employees who had been working for less than one year were excluded from the study. In Mills I, III and IV, the total population of openers through warpers was studied but in Mill II, the population of spinners through twisters was too large, so this segment of the study group was sampled using a simple random sample. In Mill II, therefore, the study population was

heavily weighted toward workers in preparation jobs (through roving) and comprised 74% of Mill II study participants. Fourteen percent of Mill I participants and 45% of Mill III workers studied were employed in preparation jobs. In Mill IV, the control plant, workers who had been employed in the cotton textile industry for over a year at some time in the past were excluded from the study.

B. Study Population

In addition to meeting the above criteria for inclusion in the study, each participant must have been off work for at least 35 hours before being tested prior to the working shift on Monday, and must have worked at least five hours before his post-shift evaluation. The information upon which inclusion was based was obtained from each participant individually as he or she reported for testing. The population defined above consisted of 524 individual potential study participants. Four of these were disqualified because they had not been off work for at least 35 hours and another 26 were unable to participate due to sickness or similar reasons. The non-participation rate was 5.7%. Of the remaining 494 individuals who completed the interview, complete pulmonary function determinations were not available for a variety of reasons, including 54 where their effort was considered sub-maximal. Such poor effort was documented in a variety of ways including "non-repeatability, slow start from the maximum inspiratory position, start at a sub-maximal inspiratory position, and inability to perform the test." The remaining individuals with incomplete pulmonary function tests were excluded for such reasons as an asthma attack, tuberculosis, tooth extraction, upper respiratory infection, or were excluded from the analyses because no dust sampling was performed in the work area of the individual. Complete analyses were performed on the population numbering 418. Details of the study participation by mill is included in Table 1.

C. Methods

1. Questionnaire

The MRC questionnaire modified for detecting byssinosis was administered to each study participant by three trained interviewers either before or after the Monday work shift. Byssinosis was defined using both the Schilling definition and a less stringent one. Chest tightness sometimes on Monday, always on Monday, and on Monday and other working days, was the primary definition of byssinosis. A secondary definition included cough, phlegm, and dyspnea, as well as chest tightness, with similar Monday periodicity. An individual was considered to have chronic byssinosis if he or she did not have Monday chest tightness at the time of the interview but recalled having had this symptom in the past and continued to have respiratory symptoms subsequent to the intermittent complaints indicated. Chronic bronchitis was defined as cough and phlegm on most days for at least three months of the year, for two or more years (MRC definition). Dyspnea was defined as shortness of breath when walking fast or walking up a slight hill.

* * * * *

IV. Biologic Response

A. Clinical Patterns

1. Byssinosis

Of 494 persons interviewed, six had unmeasured dust levels and two had incomplete answers regarding Monday chest tightness, leaving 486 for analysis of byssinosis prevalence. Table 7 shows characteristics of this study population for each mill. Byssinosis was defined as chest tightness or difficult breathing occurring on the first day back at work after days off, and abating later in the work week. This questionnaire response was given by 22 of 386 cotton workers (5.7%) and three of 100 workers in the synthetic textile (control) mill. The

response rates for each mill, exposure and smoking category are shown in Table 8.

Each cotton worker was assigned to one of three exposure categories according to the measured levels of elutriated dust in his work area. These levels were: high, 0.5 mg/m^3, or greater; intermediate, less than 0.5 but at least 0.2 mg/m^3; and low, less than 0.2 mg/m^3. Subjects who had ever regularly smoked cigarettes were considered "smokers", and all others were "non-smokers".

Questionnaire data was then analyzed using hierarchical log-linear modeling assuming that the number of study participants in each mill-exposure level-smoking category was fixed by design. Evidence of a dose-response relationship was sought by comparing prevalences of byssinosis in the four exposure categories (three cotton and one control). Table 9 shows the observed rate for each exposure level, followed by an estimated rate shown in parentheses. These estimated rates were derived from a log-linar model that specified dependence ($p = .56$ for goodness of fit as measured by -2 log likelihood ratio statistic) on exposure level and smoking, without interaction between these variables. In this analysis the prevalence of byssinosis is significantly ($p = .005$) affected by exposure level beyond the effect of smoking status.

The above analysis, however, proceeds on the assumption that given dust levels define homogeneous exposure level categories, and disregards potential effects of the individual mills. This type of analysis has been used in most of the published studies of dust exposure and byssinosis prevalence, and may be appropriate where prevalence rates are similar in the individual mills. In the present study, the prevalence rates for the mills are: Mill I, 1.1%; Mill II, 15.3%; Mill III, 1.6%; and Mill IV, 3.0%. Clearly, Mill II has a substantial effect upon byssinosis rate, and this effect cannot be ignored in analyzing the dose-response relationship.

* * * * *

Table 8

Byssinosis in Cotton and Control Textile Workers

Cotton Workers

Exposure level (mg/m^3)	High ≥ 0.5		Intermediate $<0.5, \geq 0.2$		Low <0.2	
Chest tightness:	Yes	No	Yes	No	Yes	No
Smokers, Mill I:	0	12	1	33	0	1
" Mill II:	14	55	1	9	-	-
" Mill III:	1	22	1	45	1	46
Nonsmokers, Mill I:	0	16	0	22	0	4
" Mill II:	2	22	1	14	-	-
" Mill III	0	16	0	19	0	28

Control Workers

Chest tightness:	Yes	No
Smokers	1	37
Nonsmokers	2	60

Table 9

Observed Prevalences and Estimated Rates of Byssinosis
by Exposure Level (In Parentheses)

	Cotton			Control
	High ($\geq$ 0.5 mg/m^3)	Intermediate ($<$ 0.5 and $\geq$ 0.2)	Low ($<$ 0.2)	
Smokers	14.4% (13.5)	3.3 (3.6)	2.1 (1.7)	2.6 (4.9)
Nonsmokers	3.6 (5.3)	1.8 (1.3)	0 (0.6)	3.2 (1.8)

EXHIBIT 15

Respirator Testimony for the Proposed Cotton Dust Standard

by

Bruce J. Held, CSP
Livermore, California

I. PERSONAL QUALIFICATIONS

I am Bruce J. Held with the University of California's Lawrence Livermore Laboratory. I will be discussing the respirator requirements in the proposed cotton dust standard.

My background includes a Master's Degree in Industrial Health from the University of Michigan and 20 years experience in Industrial Hygiene. In addition to 15 years as a field industrial hygienist in industry, I was the Leader of the Respirator Research and Development Section, and later the Assistant Group Leader for all industrial hygiene research and development work, including respirators at the University of California's Los Alamos Scientific Laboratory in New Mexico from 1972 through 1974. I am now the Project Leader for respirator research at the Lawrence Livermore Laboratory of the University of California. I have been a member of the American Industrial Hygiene Association since 1959 and on the Board of Directors from 1971 to 1974. I am a Certified Safety Professional, a Director on the Board of Certified Safety Professionals since 1974, currently Vice President of the Board and Chairman of its Examination Committee.

My work in respiratory protection includes authoring or coauthoring over a dozen papers on respirator research, authoring or coauthoring six books and chapters of books on respirators, member of the Joint American Industrial Hygiene Association—American Conference of Governmental Industrial

Hygienists Respirator Committee for 12 years and Chairman from 1972 to 1975, Chairman of the Atomic Energy Commission Respirator Advisory Committee in 1973 and 1974, member of the American National Standards Institute Subcommittee Z88.2 to rewrite the Standard, "Practices for Respiratory Protection," and a consultant to NIOSH and OSHA on the respirator portions of several criteria documents and proposed standards, respectively. Appended to this testimony is a detailed statement of my professional qualifications.

II. LIMITATIONS OF RESPIRATORY PROTECTIVE DEVICES

I would first like to reemphasize the desirability of controlling exposures to cotton dust by means of engineering methods. Respiratory protective devices have many limitations which make them undesirable if engineering controls are at all possible. Among the limitations of respirators are:

A. Fitting problems with persons with small faces such as many women, with persons with facial hair, such as beards or long sideburns, scars or growths which break the facepiece-to-face seal and with persons with pronounced wrinkling, a sunken nose bridge, deeply cleft chin, very narrow nose, a very wide or very narrow face, or very long or very short face.

B. Communications problems between workers wearing respirators. Any respirator will muffle voice communications to varying degrees. With many devices, the jaw movements used for speaking can break the facepiece-to-face seal and cause inleakage of contaminated air.

C. Vision problems can be numerous. Downward vision is obstructed with half or full-face masks, thus increasing tripping or stumbling possibilities. The inability to look straight down could easily cause a serious injury. Full-face respira-

tors will restrict the wearer to tunnel vision. Persons who must wear prescription glasses must be fitted with special glass kits for full-face masks, as the temples of regular glasses break the facepiece-to-face seal. Some persons also have problems wearing glasses with half-masks, as the respirator either pushes the glasses above the eyes or the glasses come between the mask and the face around the nose, thus breaking the facepiece-to-face seal.

C. Fatigue and reduced efficiency occur more quickly among workers wearing any type of covering over the face or head. This is caused by many factors, among them being increased breathing resistance, heat, some possible feelings of anxiety from being closed in and reduced vision. On many jobs we have permitted or required 15 minute breaks every one or two hours while wearing a respirator, rather than the usual one coffee break in the morning and one in the afternoon.

D. Some persons, for reasons of health, would not be permitted to work if they had to wear a respirator. A person with a heart problem may not be able, for example, to wear a 30 or 35 pound self-contained breathing apparatus. Persons with some lung problems such as emphysema may not be able to stand the increased breathing resistance inherent in any respirator.

For these reasons and others which I did not enumerate, it must be emphasized that respirators are a second line of defense, to be used only when engineering controls are not feasible. In other words, respirators are cumbersome, expensive, reduce worker efficiency and may create hazardous situations to a worker and I fully concur with the limitations put on the use of respirators in paragraph (F) of the proposed standard.

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EXHIBIT 16

Research Triangle Institute, Technological Feasibility and Economic Impact of Regulations for Cotton Dust

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III. *Technological Feasibility*

A major part of the effort of RTI's study was devoted to assessing the feasibility of implementing each section of the proposed standard. There was little difficulty in establishing the feasibility of the provisions for medical surveillance and workplace monitoring. The technological feasibility of alternative methods of providing protection for workers at various exposure limits was much more difficult to determine. RTI's approach to these problems was essentially as follows.

Two steps were taken at the outset: first, to obtain a description of the production processes involved in each of the industry sectors to be studied so that the sources of dust could be determined, and second, to search the published literature for data and analyses of dust controls applicable to cotton processing. It was apparent quickly that some data related to the production of cotton yarn were available, but that data on other cotton processing operations were limited or almost nonexistent.

Studies of yarn manufacturing indicated that cotton dust is generated at each step in the process, but that dust levels in the rooms where these processes were carried on were progressively lower at each step. Thus, the dust levels reported tended to be above 1.0 mg/m^3 for opening, picking, and carding, between 0.5 and 1.0 mg/m^3 for drawing and roving, and between 0.2 and 0.5 mg/m^3 for spinning, winding and twisting. Depending therefore on the exposure limit under consideration, dust controls would be required on some or all of these operations. Much higher dust levels were indicated for clean-up operations, including blow-down of machines and sweeping, and also for the waste room.

Studies of other segments of the cotton industry indicated dust levels requiring control under the proposed standard for the following processes: the gin stand and bale press for cotton gins; the seed house and the delinter for cottonseed oil mills; slashing and warping, and weaving in weaving mills; the garnetting room in cotton batting production; and on all steps from opening to winding in the production of yarn and felt from waste.

At this point in the study, it was apparent that published data would permit identification of dust sources and existing dust levels in the industry sectors mentioned above, but at least two important segments, knitting and carpet manufacturing, were not covered. Subsequent inquiry of industry sources failed to fill this gap in the data and it was decided to exclude these two industry sectors from the study.

It is OSHA policy to prescribe the use of engineering controls to achieve designated worker exposure limits to the extent that they are feasible. If engineering controls cannot reduce dust levels to the prescribed levels, they are then to be supplemented by required work practices that reduce exposure to dust and, if necessary, personal protective equipment (respirators) are also required. RTI has followed this control hierarchy throughout the study.

Engineering controls may be defined as methods designed to collect and remove dust from the air, either by capturing the dust at its source or through general ventilation and air filtration. They also include modifications of production equipment and procedures to reduce dust emissions, and substitution of materials to reduce or eliminate the toxic components of emitted dust. Engineering controls may be retrofitted onto existing equipment or built into new equipment.

Engineering controls of the dust levels in rooms containing any of the above production processes tend to

employ general room ventilation with filtration of the recirculated air, and local exhaust ventilation, again with the air filtered and recirculated. All yarn mills and most other cotton processing establishments, except gins, are air conditioned, with the air recirculated and supplemented by a limited amount of make-up air as needed. Although some filtration is built into any air conditioning system, these systems have not in the past been designed to maintain very low dust levels. Their dust removal efficiency can be enhanced by the installation of multistage filtration systems, but where the dust sources are substantial, achievement of room dust levels in the range under consideration for this standard requires the application of local exhaust ventilation (LEV) as well. Although RTI did not undertake the design and testing of LEV systems, the discussion in the next section on the design principles utilized may clarify the nature of these controls.

* * * * *

On the other hand, the existing regulation specifies an exposure limit of 1.0 mg/m^3, 8-hour time weighted average. The costs related to compliance with exposure limits of 0.5, 0.2, and 0.1 mg/m^3 were calculated as the increased cost required to achieve those levels, starting from a system of controls that would already maintain dust levels at or below 1.0 mg/m^3. Each cost figure given represents the increment required above the costs at the 1.0 mg/m^3 limit. In other words, the costs estimated for compliance at the 0.2 mg/m^3 exposure limit, for example, are incremental over the cost of compliance with the 1.0 mg/m^3 limit, not the increment required to go from 0.5 mg/m^3 to 0.2 mg/m^3. These estimates are not based on the assumption of step-wise compliance with increasingly stringent standards over time.

* * * * *

The capital (installed) costs of engineering controls for use in the yarn producing sector were calculated for

systems to provide room dust levels in compliance with exposure limits of 0.5, 0.2, and 0.1 mg/m^3. These are shown in Table 7, along with the corresponding maintenance and operation, energy, and labor costs, by unit of equipment used in yarn production. Similar estimates were made, to the extent possible, for other industry sectors and these will be discussed subsequently. Tracing our analysis of yarn industry costs will serve to illustrate the methods used throughout.

Estimation of these costs by unit of equipment provided the basis for projecting costs by SIC classification, which was necessary for analysis of economic impact. To make the transition from individual machine cost to industry cost it was necessary to estimate the number of machines in use to produce cotton yarn. Unfortunately, no inventory of cotton textile machinery showing the necessary detail was available. Aggregate data for some equipment types were available from a census study in 1973 and these were combined with information reported by the American Textile Manufacturers Institute covering 1972 or 1973 and related in turn to data on cotton consumption to estimate the number of machines in use.

Textile equipment was divided between cotton and other fiber processing on the assumption that 55.1 percent of the machines process cotton only and 31.5 percent process blends of cotton and synthetic fiber that average 50 percent cotton. This follows an industry division reported by ATMI in 1973 for spinning spindles and was assumed to apply to other equipment equally.

The available data indicated fairly certainly the number of chute-fed and conventional cards in use. Using other data from various sources, a model of the combinations of machines used in typical configurations was developed. Thus, it was assumed that an opening system consisted of three blending hoppers serving a picker. In turn, three pickers were assumed to be associated with each opening system employing pickers. An additional

number of opening systems was assumed for systems with direct chute feed to the card. These ratios were applied to the estimated number of pickers in use and the estimated number of cards in use provided an estimate of the number of opening systems and components, which was apportioned by fiber type processed. In the same way, the numbers of drawing frames, combers, rovers, and open-end and ring spinning frames were estimated. These estimates were combined with estimates of the flow of cotton through the production system, divided by type of operation employed, as shown in Figure 4. Machine costs per pound of cotton processed could then be allocated to estimate aggregate costs.

In this way a model representative of the average firm was developed and the cost per firm estimated. When multiplied by the number of firms in the yarn industry, this helped to estimate industry cost by SIC. It is important, at this point, to emphasize that the model plant is just that, and not a representation of any actual firm. Plant configurations differ considerably from one firm to another depending on the brand of equipment used, the type of product produced, and the quality of cotton processed. RTI did not have an accurate inventory of each type of machine now in use or of the plant configurations. Numbers of machines in use were estimated on the basis of productivity and quantity of cotton processed in a year. They differ then depending on the base year used, as in Table 8. Some degree of error may have been introduced by the estimation process used, but it is felt that the estimates given are a reasonably accurate representation of the expected cost.

Similar analysis was made of each of the other industry sectors covered. Costs were then aggregated and annualized in the subsequent analysis of economic impact. Total initial and recurring (annual operating and maintenance) costs for yarn producers are shown in Table 8.

* * * * *

G. *Implementation*

In the course of this study RTI alerted OSHA to some of the difficulties that the cotton textile industry might encounter in complying with the proposed standard. Two factors, in particular, were identified: (1) the development, production, and installation of control equipment by the control industry, and (2) the ability of textile firms to finance the capital investments required. Neither of these is completely intractable given enough time.

Estimates of the time required for the cotton textile industry to come into compliance with the proposed standard cannot be made with certainty. A large number of firms are involved and each one will have special conditions constraining its actions. Nevertheless, after consultation with textile firms and suppliers of control equipment, and consideration of normal business practices and the experiences of other industries, RTI suggested that compliance by the yarn producing sector with an exposure limit of 200 $\mu g/m^3$ would, it was estimated, take as much as eight or more years. For other sectors of the cotton textile industry, RTI estimated that compliance at each exposure level could require two to three years more than for yarn producers.

The primary basis for these estimates was the problems the control industry may have in supplying required equipment. Each installation will tend to be a custom design for that plant and at best there will be considerable time required to complete and test the installation. For some equipment, also, entirely new designs will be needed and such new technological applications will not be available immediately, even though the general methods to be used are known.

Financing will also be a problem for many firms. RTI was not able to estimate the extent of this problem since detailed financial information for each firm is not available.

Implementation of the proposed standard will require adjustments within the cotton textile industry that will take time to work themselves out and that may be difficult for many firms. In time, however, prices may be expected to rise and markets to adjust so that revenues will cover costs. Although the impact on any one firm cannot be specified in advance, nothing in the RTI study indicates that the cotton textile industry as a whole will be seriously threatened by the impact of the proposed standard for control of cotton dust exposure.

EXHIBIT 26

Memorandum to Grover C. Wrenn from Dr. James A. Merchant

SUBJECT: Review of Draft Proposal for Cotton Dust Standard

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Throughout the document byssinosis *incidence*, rather than *prevalence* is discussed. In every case, *prevalence* rather than *incidence* is the correct designation as the data collected was cross-sectional in nature rather than longitudinal.

* * * * *

EXHIBIT 38A

Statement of Edward J. Baier

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Occupational exposure to cotton dust was high on the NIOSH list of priorities and was the subject of one of the first criteria documents issued. The cotton dust criteria document (Appendix 1), was transmitted to the Occupational Safety and Health Administration in September, 1974 and recognized that there were significant gaps in the etiology of byssinosis and that there was no definitive environmental level which would assure complete health protection for exposed workers. For these reasons the thrust of the criteria document was for medical management and surveillance of workers *combined* with implementation of engineering controls and work practices to limit worker exposure to the lowest level feasible. In December 1974, NIOSH clarified the term "lowest feasible limit" and recommended that this limit should not be higher than 0.2 mg lint-free cotton dust per cubic meter of air but concluded that even at this level byssinosis would occur among exposed workers. (Appendix 12)

* * * * *

MEDICAL SURVEILLANCE

Because it is well recognized that byssinosis and other biological effects occur at dust levels below 0.2 mg/m3, it is mandatory that an effective medical surveillance program be an integral part of this standard. Conversely, without good environmental control, an effective medical surveillance program is not possible; that is only a small proportion of workers can be effectively reassigned. Clearly a surveillance program without the means to transfer affected workers is ineffective. Therefore, the proposed rules must address not only methods of surveillance, but criteria for the management of affected workers.

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EXHIBIT 38D

Merchant, "Epidemiological Studies of Respiratory Disease Among Cotton Textile Workers"

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Cross-sectional studies of American cotton textile workers[6,21,33,34,49,51] have established that respiratory disease is common among workers exposed to cotton dust and similar in magnitude and distribution to that previously observed in the British cotton textile industry.[17,32,41,45,46] At the time the present study was begun, there was a need to better define the extent and specificity of pulmonary disease in a large population over a wide range of textile processes and dust levels, particularly in the rapidly expanding cotton/synthetic blend industry. New dust sampling techniques were under development[26] which promised to provide a simple and reliable method for determining lint free dust levels, but needed field testing and correlation with biological parameters of pulmonary dysfunction. Objective measurement of pulmonary function before and after exposure to vegetable dusts was known to produce both acute[10,27] and chronic declines[5,7,9] in ventilatory capacity, but had not been evaluated in a sufficienty large cotton textile population together with an appropriate control population. Few previous studies of respiratory disease in textile workers[14,41] had contained enough subjects to allow for estimation of risk factors relative to measures of respiratory dysfunction. Vegetable dust concentration, when crudely defined by work area [14,33,41] or measured quantitatively,[1,2,41,45] was known to be an important factor in determining byssinosis prevalence and acute decrement in ventilatory capacity. Available data suggested that smoking also affected byssinosis prevalence[14,48] as well as bronchitis prevalence and ventilatory capacity, and that vegetable dust exposure and smoking might interact to produce more severe pulmonary effects.[28,33] Further investigation

was needed to better define these relationships on respiratory disease prevalence and ventilatory function while accounting for other factors such as age, sex, and duration of dust exposure.

Accordingly, a study was designed with three primary objectives. First, to establish the prevalence of byssinosis and other respiratory diseases under diverse working conditions representative of those common to the primary U.S. textile industry. Secondly, to evaluate the vertical elutriator cotton dust sampler[26] as a method to determine lint free dust levels and develop dose-response relationships to help formulate a target toward which environmental control could be directed. Thirdly, to evaluate risk factors and their possible interactions associated with pulmonary dysfunction among textile workers. Byssinosis prevalence and Monday decrement in ventilatory capacity relative to lint free dust levels as determined in this study have been subjects of previous communications.[34,35] The purpose of the present communication is to describe analyses of determinants of respiratory disease, specifically byssinosis, bronchitis and dyspnea prevalence, and four measures of ventilatory function, forced vital capacity in one second ($FEV_{1.0}$), change in $FEV_{1.0}$ with dust exposure ($\triangle FEV_{1.0}$), forced vital capacity (FVC), and change in FVC with dust exposure ($\triangle FVC$).

* * * * *

It must be stressed that the cross-sectional nature of this study dictates that the probability (P) determined in these analyses is the probability that a subject has the disease at the time of observation, rather than the probability of developing the disease. Significant variables used to determine P were selected by accepting those that provided a partial F greater than 3.84 which is the 95th percentile of an F distribution with one numerator and infinite denominator degrees of freedom. Using this criteria, the sets of variables that best dis-

criminated between the presence or absence of byssinosis and bronchitis were determined. Using these linear discriminant functions, subjects were classified by whether they were predicted to have and by whether they were actually observed to have byssinosis or bronchitis allowing calculation of the respective sensitivity and specificity of the functions. As an estimation of the goodness-of-fit of the linear discriminant function, subjects were categorized into deciles of decreasing risk. The expected number of cases was then compared to the number of observed cases.

* * * * *

EXHIBIT 39

Morgan, *et al.*, "Report on Survey on Prevalence of Byssinosis and Respiratory Symptoms in Three Textile Mills"

INTRODUCTION

At the request of Burlington Industries, the Division of Pulmonary Diseases of the University of West Virginia carried out a survey of the prevalence of respiratory symptoms and byssinosis in three mills. The mills were situated in Brighton Georgia, Clinchfield, near Marion North Carolina and at Ranlo near Gastonia North Carolina. The first two both use cotton fiber while the third one only uses synthetic fiber.

Each participating subject had a respiratory symptoms questionnaire administered to them, the latter being based on the British M.R.C. questionnaire. Schilling's additional questions concerning the symptoms of byssinosis were also included.[1] Participation was voluntary. Spirometry was used to determine ventilatory capacity and was administered both before and after a shift. At least four forced expiratory volume maneuvers were recorded on a Jones Pulmonor. When the tracings were not reproducible, additional forced expiratory volume maneuvers were performed. More precise details of methodology are given later in the section of the report dealing with ventilatory capacity.

It will be observed that in some instances disparities exist between the number of subjects completing the questionnaire and those undergoing pulmonary function testing. While the questionnaire was administered at the worker's convenience any time throughout the working week, the pulmonary function tests had to be done in a short period prior to beginning work and then again at the end of the shift. Owing to the large number of subjects being tested, in some instances, workers became impatient when required to wait for more than a few

minutes and left prior to being tested. This was especially true at the end of the shift. In other instances, workers attended once only for their spirometric measurements. In carrying out the spirometric assessment of ventilatory capacity, every effort was made to include as many as posible of the card room workers and spinners with the result that a significantly greater percentage of workers completed this part of the examination.

Measurements of ventilatory capacity were accepted as valid only when the three largest forced vital capacities (FVCs) and the three largest forced expiratory volumes in one second (FEV_1) were all within 10% of each other. These criteria were used in order to insure adequate quality control. All measured values were compared to the predicted values of Morris and co-workers.[2] In this regard, it must be borne in mind that the nomogram derived by the above workers was base on a population of non-smokers and as a result the predicted values are somewhat higher than those of Kory et al.[3]

Prevalence of Byssinosis and Other Respiratory Symptoms by Questionnaire

The standard MRC questionnaire on Respiratory Symptoms was administered to all subjects who agreed to participate in the survey. In addition to the standard questions on respiratory symptoms, Schilling's supplementary questions were administered in order to ascertain the prevalence of the various grades of byssinosis. The severity of byssinosis was graded as follows:

Grade ½. Occasional chest tightness on Monday or the first day of the week.

Grade 1. Regular chest tightness or difficulty breathing on the first day that work was resumed.

Grade 2. Chest tightness and difficulty breathing not only on Monday, but on other days of the week.

The questionnaire was administered by 6 persons of whom two were pulmonary function technicians, one a physician, and three medical students. All persons administering their Questionnaires had been trained and instructed in its use according to the instructions published by the MRC.[4]

Prevalence of Byssinosis

Of the 271 subjects to whom the Questionnaire was administered in Mill B, one admitted to the symptoms of byssinosis (Table 1). At the second mill (C), again two subjects out of the 449 to whom the Questionnaire was administered complained of chest tightness (Table 2). In the third mill (R) in which only synthetic fiber is used, again one subject out of the 240 who completed the Questionnaire stated that he had symptoms of byssinosis (Table 3).

Shortness of Breath

Breathlessness was graded from 1 to 4 by the following criteria. If the subject was troubled by shortness of breath when hurrying on level ground or walking up a slight hill, this was graded as 1. Grade 2 was present when the subject was short of breath walking with other people of his own age at an ordinary pace on level ground. Should the person have to stop for breath when walking at his own pace on level ground, this was graded at 3. Shortness of breath upon washing or dressing was graded as 4.

The prevalence of shortness of breath by grade in Mill B is shown in Table 4. 55 out of the 246 (22%) card room workers complained of some degree of shortness of breath. Corresponding figures for Mill C are shown in Table 5. There 11 out of 41 (26%) of card room workers complained of some degree of shortness of breath. In the spinning room 12 out of 81 (14.8%) had some shortness

of breath, while in the weaving room 31 out of 183 (16%) admitted to this symptom.

In Mill (R) 10 out of 47 (21%) of the card room workers admitted to shortness of breath (Table 6). The corresponding figures for the winding and spinning rooms were 23 out of 70 (32.8%) and 20 out of 51 (39%).

* * * * *

The Relationship of Shortness of Breath to Byssinosis and Cigarette Smoking

The relationship between byssinosis and shortness of breath is shown in Tables 10, 11, and 12. No obvious correlation is apparent because of the paucity of subjects with the symptoms of byssinosis. For the most part, it is evident that there is a clear cut association between shortness of breath and cigarette smoking.

The smoking habits of the millworkers according to their job and workplace are shown in Table 16, 17 and 18.

* * * * *

Conclusions

In all three mills there was a very low prevalence of byssinosis; indeed there was only one subject in Mill B and two in Mill C who admitted to symptoms of chest tightness. Similarly the prevalence and severity of shortness of breath did not differ between the three mills, nor was this symptom any more prevalent in the cardroom workers. A significant number of subjects had a reduced ventilatory capacity, but this appeared to be associated with cigarette smoking rather than exposure to cotton dust. It is concluded that byssinosis is distinctly uncommon in the workers examined and does not constitute a significant hazard in these three groups of millworkers.

EXHIBIT 39A

Supplemental Submission to Statement and Testimony of W. K. C. Morgan, M.D.

The data and information contained herein is made as a supplement to the oral testimony given at the hearings on the Proposed Cotton Dust Standard on April 20 and 21, 1977 (Transcript, pp. 1351-1373, 1424-1512), to the written statement submitted on April 1, 1977 (Exhibit No. 40) for the record as part of the American Textile Manufacturers Institute, Inc. presentation and to the study submitted during the hearing (Exhibit No. 39, Transcript, p. 1424), hereinafter "Study."

During the oral testimony, representatives of various organizations requested that certain data and information be furnished. Information requested, showing the name of the individual making the request and the page of the transcript where the request was made, is as follows:

1. The number of subjects in each of the mills surveyed in the Study who were rejected because their pulmonary function tests, either before or after a shift, did not meet the criteria for reproducibility utilized in the Study were as follows:

Mill B	Mill C	Mill R
59	25	48

In this regard, it must be noted that, in many instances, these subjects' before shift tests met the criteria, but the subjects did not return for an after shift test or the after shift test did not meet the criteria. In such event, the before shift test was used to compare with the subjects predicted value and include in the figures in the appropriate part of the Study. (Ms. Simmons, p. 1428)

2. The questionnaire used in the Study is attached hereto as Attachment "A". (Dr. Merchant, p. 1480)

3. The average or mean age, by sex, of the employees at each of the mills surveyed and who formed the basis for the prevalence rate was as follows:

	Mill B	Mill C	Mill R
Male	37.46	39.46	38.16
Female	38.77	37.16	38.55

(Dr. Merchant, p. 1485)

4. The statistical test utilized to determine the statistical significance of the data in Tables 33 and 34 of the Study was the Students T Test. (Mr. Haymes, p. 1508)

5. The pulmonary function testing was commenced at Mill B on Sunday, January 11, 1976, and on Monday, January 19, 1976, at Mill C. (Ms. Simmons, p. 1425, Dr. Merchant, p. 1476)

EXHIBIT 40

Statement of W.K.C. Morgan, M.D., Professor of Medicine, West Virginia University School of Medicine, Division of Pulmonary Diseases

While the term byssinosis represents a fairly distinct entity to the clinician, its recognition is far from simple and no simple precise definition of the condition can be given. The symptoms of chronic bronchitis and those of byssinosis are similar and, in many instances, it is difficult to unravel the effects of cigarette smoking from those of the inhalation of cotton dust. In various studies, different clinical aspects of the condition have been emphasized. Thus, while some surveys have defined byssinosis in terms of the response to Schilling's modification of the MRC questionnaire (Schilling questionnaire), others have relied on the decrement in ventilatory capacity that occurs over a shift to characterize the condition, while yet others have preferred to look at the overall ventilatory capacity of cotton workers as compared to comparable controls. No doubt all of these manifestations of the condition are important, however, nowhere in the OSHA proposed standard for cotton dust is it clearly stated which of these features of byssinosis the standard has been designed to control. The general impression is left that the adoption of the standard will have equally beneficial effects on all the various features of the condition, despite the fact that the evidence available suggests that the anuual decrement in forced expiratory volume in one second (FEV_1) appears to be unrelated to symptoms of byssinosis, bronchitis or dust levels.[1]

Many of the arguments used in favor of the proposed 200 u/m^3 are based on the prevalence of symptoms as defined by the Schilling questionnaire. Indeed, frequent reference is made to the investigations of Merchant et al.[2,3] and of Molyneux and Tombleson[4] in which the prevalence of byssinosis was related to particular levels of

dust. First, in this context, I feel it is unwise to regard the questionnaire as a precise instrument of mensuration since it is quite clear that the response to the questions varies not only with the interrogator, but the same subject will frequently answer the same question in a different fashion on a different occasion.[5] Thus, personal experience has shown that the prevalence of respiratory symptoms can be doubled or tripled by changing the tone and emphasis of the questions so that a tendentious inflection is given to the manner in which the question is asked. For this reason the MRC of Great Britain has published a monograph giving instructions on the use of their questionnaire.[6] Second, as the document proposing the standard makes clear, the shift decrement in ventilatory capacity is related poorly to the symptoms of byssinosis, viz. chest tightness, etc. Third, the relationship, if any, of an increased annual decrement in FEV_1 and FVO, etc. to a Monday morning shift decrement is unknown and remains conjectural. Clearly any standard should be primarily concerned with preventing a greater than normal annual decrement in ventilatory capacity. To strive by means of an exceptionally stringent standard for the elimination of Grades ½ and 1 as defined by Schilling or the elimination of a non sustained transient drop in the FEV_1 serves little purpose if in doing so the textile industry as a whole is placed economically in jeopardy. In this regard I do not believe at the present time there are sufficient data available to justify the stringent standard proposed by OSHA, an opinion that is based on a recent field study along with a careful consideration of the other available evidence.

At the request of Burlington Industries, the Division of Pulmonary Diseases of the University of West Virginia carried out a survey of the prevalence of respiratory symptoms and byssinosis in three textile mills. The mills were situated in Brighton, Georgia (Mill B);

Clinchfield, North Carolina (Mill C); and Ranlo near Gastonia, North Carolina (Mill R). The first two used cotton fiber while the third processed only synthetic fiber.

Each participating subject had the respiratory symptoms questionnaire of the MRC administered to them along with supplemental questions devised by Schilling. Participation was voluntary. Spirometry was performed before and after a shift. At least four forced expiratory volume maneuvers were recorded on a Jones Pulmonor. When the tracings were not reproducible, additional maneuvers were carried out. Measurements of ventilatory capacity were accepted as valid only when the three largest forced vital capacities (FVCs) and the three largest forced expiratory volumes in one second (FEV_1s) were all within 10 percent of each other. These criteria were used in order to ensure adequate quality control. All measurements were compared to the predicted values of Morris and co-workers.[7] In this regard, it must be borne in mind that the nomograms derived by Morris were based on a population of nonsmokers and, as a result, the predicted values were somewhat higher than those of Kory et al.[8]

PREVALENCE OF BYSSINOSIS AND OTHER RESPIRATORY SYMPTOMS BY QUESTIONNAIRE (TABLES 1-3)

The severity of byssinosis was graded from the questionnaire in the usual fashion. The questionnaire was administered by six persons of whom two were pulmonary function technicians, one a physician and the remaining three medical students. All had been previously trained in administering the questionnaire according to the instructions published by the MRC.

Of the 271 subjects to whom the questionnaire was administered in Mill B, one admitted to the symptoms of

byssinosis (Table 1). In the second mill, two subjects out of the 449 complained of chest tightness (Table 2). In the third mill in which only synthetic fiber was used, only one subject out of the 240 who completed the questionnaire admitted to symptoms of byssinosis (Table 3).

SHORTNESS OF BREATH (TABLES 4-6)

Breathlessness was graded from 1 to 4 by the following criteria: if the subject was troubled by shortness of breath when hurrying on level ground or walking up a slight hill, this was graded as Grade 1. Grade 2 was present when the subject was short of breath when walking with other people of his own age at an ordinary pace on level ground. Should the person have to stop for breath when walking at his own pace on level ground this was graded as Grade 3, and shortness of breath when washing or dressing was graded as 4. The prevalence of shortness of breath by grade in the three mills is shown in Tables 4 through 6. The prevalence of shortness of breath in the card room workers of the three mills was as follows: 22.3% for Mill B, 26.8% for Mill C and 21.2% for Mill R. These figures are not statistically different. There was a clear cut relationship between shortness of breath and cigarette smoking, but owing to the fact that so few subjects had symptoms of byssinosis, it was not possible to show a relationship between the presence of shortness of breath and byssinosis.

* * * * *

In conclusion, there is not enough evidence to justify the proposed stringent standard. Most studies have suggested that there is no threshold level below which no cases of byssinosis will occur. While this concept may be correct, it is not necessarily so, and the attempt to promulgate an excessively low standard in order to reduce the prevalence of byssinosis to almost zero may be doomed to failure. Some of the subjects with byssinosis who are

working in areas where the dust levels are negligible may have developed the condition while working elsewhere, and have subsequently changed their job. Hence, their symptoms could well be a reflection of past rather than present exposure. This situation is more likely to be true for symptoms of byssinosis than it is for a decrement in FEV_1. Symptoms of byssinosis in the absence of a past shift decrement in ventilatory capacity should be viewed with caution.

Next, it is not clear whether the purpose of the proposed standard is to prevent (a) the symptoms of byssinosis, (b) the Monday morning decrement in ventilatory capacity, or (c) to reduce to a normal level the annual decrement in FEV_1 and FVC. Without a clear indication of the effects of the proposed standard on the above manifestations of byssinosis, it would seem wiser to adopt a more pragmatic and liberal approach since this permits a future lowering of the dust level as more information becomes available. A too stringent standard has more serious implications and could lead to serious and permanent economic damage to the industry before the necessary relaxation can be put into effect.

EXHIBIT 41

Statement of Russell A. Harley, M.D., Associate Professor, Department of Pathology, Medical University of South Carolina

I am Russell A. Harley, Associate Professor in the Department of Pathology of the Medical University of South Carolina. Over the past five years in dealing with research projects on byssinosis[1], I have been involved in the identification of subjects to whom that term may appropriately apply. The purposes of these projects have been to seek reactions to well-defined types of cotton dust and to search for evidence of an immunologic reaction in byssinosis. I found it possible to identify some subjects with "byssinosis" with considerable confidence, but in other cases this was difficult. This statement includes observations and conclusions drawn from this experience.

A major problem in dealing with byssinosis has been the variety of conditions included under the term. Definitions range from nebulous transient feelings of discomfort to crippling disease. Logical and appropriate action demands clarity of terminology. Every effort must be made to avoid using the word "byssinosis" without appropriate modifiers.

Consider the following definitions of the term with the words in parenthesis. Some of those terms which have been loosely and carelessly used to describe "byssinosis":

A. *ACUTE BYSSINOTIC REACTION* (byssinosis, acute byssinosis, Monday asthma, reactor state, etc.):

1. *Subjective:* a feeling of chest tightness worse on Mondays or the first day back at work after an absence.

   (a) Grade ½ byssinosis: feeling present on some Mondays.

(b) Grade 1: every Monday but not other days.

(c) Grade 2: Monday and other days.

2. *Objective:* 5% to 10% or greater decrement in FEV_1 (or other objective evidence of bronchoconstriction) worse on Mondays or first day back at work.

B. *CHRONIC OBSTRUCTIVE BYSSINOSIS* (byssinosis, grade 3 byssinosis, byssinosis with disability, etc.): Permanent chronic obstructive pulmonary disease (COPD) occurring as a result of cotton dust exposure.

There are varying degrees of severity of both of these. Grade ½ "byssinosis" is a nebulous entity, probably useful in epidemiologic work, but hardly acceptable as a "disease". Any attempt to estimate the prevalence of the Monday phenomenon, the key criteria for a finding of byssinosis, which utilizes Grade ½ should be regarded with scepticism since many persons not at risk of byssinosis feel the subjective symptoms of shortness of breath or chest tightness on "some Mondays". Data drawn largely from healthy working persons should not be used to imply the presence of massive numbers of *disabled* workers in the textile industry. This is not meant to minimize a very real problem but simply to point out that understanding this problem requires accurate terminology. Likewise, hidden within the term chronic obstructive byssinosis, or Grade 3 byssinosis, is a range of disability from the verge of normalcy to severe disease. When standard tables of predicted pulmonary function data are used in applying the term, some people who *are* normal are included in this category.

Schilling's original classification of byssinosis (Grade ½, 1, 2), a classification of subjective symptoms only, has been a useful tool in some epidemiologic studies.

However, it should be borne in mind that many persons show the functional change of the acute byssinotic reaction but are not aware of it. Thus, from a practical standpoint, objective evidence, e.g., pulmonary function tests, of the acute reactor state has proved much more useful.

Finally, in widely used modifications of the classifications where Grades ½, 1, 2, 3 appear in an orderly sequence, the assumption is often made that the disorder progresses from ½ to 1 to 2 to 3 and, thus, all grades reflect the progress of the individual's disability. In many instances, however, there is no progression at all. Sometimes Grade 3 seems to appear *de novo*, or there is a jump from 1 to 3. Among those who develop permanent disability, Grade 2 very often never occurs.

DIAGNOSIS OF THE ACUTE BYSSINOTIC REACTION

Although subjective data are important and should never be ignored, my experience, and those of others, has shown that objective criteria are most useful in making this diagnosis. A standard questionnaire is a useful tool in identifying probable reactors and if taken together with objective data such as pulmonary function tests should lead to a more careful medical history.

It must be noted, however, that many instances of what appears to be acute byssinotic reaction on an objective basis will disappear upon subsequent retesting. The original decrement may be associated with a cold, for example, or other condition which the examiner has neglected to note; or is the result of the diurnal variation which is sufficiently great in some individuals that the higher level of FEV_1 is normal for the individual for the time of day at which the original test was made; but in most cases it is simply unexplained. The incidence

of apparent acute reactive byssinosis will frequently drop to half the original number upon subsequent retests. Thus, it is evident the diagnosis of acute byssinotic reaction should not be based on a single examination as is usually done in most epidemiological studies.

The difficulty of diagnosis of the acute byssinotic reaction is, even with these tools, prominent. Bronchial hyperreactivity is well recognized in asthmatics, who are, of course, present everywhere in the general population, and the problem of asthma in the textile industry in our experience is as great or greater than that of byssinosis. The variations in bronchial constriction in asthmatics is generally a prominent feature of their pulmonary function tests and is usually not related to byssinosis. Asthmatics are at great risk of developing disabling lung disease and are not immune to the adverse effects of cotton dust. Determining the onset of the acute byssinotic reaction in the population of asthmatics may be difficult or impossible. Additionally, the development of hypersensitivity to elements in the mill environment may appear and should be watched for carefully. This is not byssinosis but nevertheless is a distinct hazard of this peculiar population which deserves increased attention.

The acute reaction becomes more prominent the longer the subject is away from dust. Many people really notice the feeling of chest tightness only after return from vacation. Return from vacation is a particularly opportune time for pulmonary testing of persons in whom the presence or absence of the reaction is questionable.

Further, many workers prevent or abort the acute reaction by the use of medication. This may be over-the-counter self medication or may be medication prescribed by a physician. This is a point which is frequently neglected and needs to be taken into account. The assistance of a qualified allergist in handling persons with hay fever and asthma in the mill situation is often necessary.

Finally, with regard to the symptom of cough, its association with bysinosis is not clear. The cough may be stimulated by the inhalation of cotton dust in byssinotics and non-byssinotics and, of course, occurs in a variety of other conditions including some not primarily related to the lung, e.g., heart disease.

CHRONIC OBSTRUCTIVE BYSSINOSIS

Over many years, the inhalation of cotton dust may result in chronic obstructive lung disease. Excluding asthma, chronic obstructive lung disease generally means chronic bronchitis and/or emphysema.

Chronic bronchitis is a disease involving the airways and is associated with chronic cough and the production of sputum. Such a productive cough is frequently found in persons with chronic obstructive byssinosis, but this is especially true in smokers. Chronic bronchitis is most commonly caused by cigarete smoking, viral infections, or chemical fumes.

Cigarette smoking may also result in certain forms of emphysema. Emphysema may, however, occur in the absence of cigarete smoking or chronic bronchitis and in such cases is sometimes associated with a congenital blood protein deficiency (alpha-1 antitrypsin deficiency). In circumstances where chronic obstructive byssinosis is not associated with a productive cough, the site of involvement in the respiratory tract is probably either in the small airways or in the alveoli. Involvement of the alveoli would probably be in the form of pulmonary emphysema, a disease in which alveoli are hyperinflated and disrupted.

Chronic obstructive lung disease caused by inhalation of cotton dust (chronic obstructive byssinosis) may occur independently or may be superimposed upon chronic bronchitis and/or emphysema of other etiology. In our

experience, most cases of disabling chronic obstructive lung disease in persons with byssinosis appears to be caused by a combination of cigarette smoking and inhalation of cotton dust. In some instances, it is virtually impossible to say what part was played by the various offending agents. In other cases, a careful history will tend to incriminate one factor more than another, and in this respect, it will be found that cigarette smoking is responsible for more lung disease in textile mills than is cotton dust.

The precise pathology of chronic obstructive byssinosis is not yet known. Likewise, the pathology underlying the acute reaction is not yet clear. A major reason for the lack of knowledge concerning the basic nature of these conditions has been a poor understanding of their symptoms among the medical community. This fault is rapidly being corrected, but at present the medical personnel having the most direct experience and understanding of practical aspects of the problem are the physicians employed by some of the larger textile companies.

* * * * *

The danger from inhaling cotton dust is not the same type or degree of inhalation of inorganic dusts such as silica, asbestos, etc. These latter substances cause fibrosis and result in a small, scarred lung with restrictive disease, quite the opposite of chronic obstructive byssinosis. Finally, there is no evidence that byssinosis is related to cancer as are asbestosis and tobacco smoking.

* * * * *

The degree of reversibility of chronic obstructive byssinosis (stage 3 byssinosis) has yet to be thoroughly examined, even in prospective studies such as that of Berry, Molyneux and Tombleson.[2]

ABNORMAL PULMONARY FUNCTION VALUES IN OTHERWISE NORMAL PERSONS

Although I have emphasized the importance of the pulmonary function tests in the proper diagnosis of the acute byssinotic reaction and chronic obstructive byssinosis, it must be recognized, lest people be badly misled, regarding the use of test data that a significant percentage of textile employees with no evidence of byssinosis or other respiratory disease by history, physical examination, or X-ray will have abnormally low vital capacities and FEV_1 values. These include the following groups:

(1) Certain of the black population, especially tall, thin, black males.

(2) Overweight and middle aged or older females with small muscle mass.

(3) Others (e.g., persons with physical deformities of the upper respiratory tract, nose and mouth, etc.).

* * * * *

In the absence of a clear, scientifically proved link between the Schilling grades (½, 1, 2) and permanent disability, a matter of priorities arises. One assumes that the objective of the expenditure of money and energy by the textile industry should be the complete and absolute prevention of permanent disability (chronic obstructive byssinosis) among its employees. The total elimination of the reversible and often unnoticed acute reaction is clearly a second priority item. Discomfort from this reversible reaction can and should be eliminated, but a mild drop in FEV_1 on Monday unnoticed by the worker should simply serve notice to the medical personnel that this person may be at increased risk of developing COPD. The employee should, of course, be retested several times to document the reliability of this datum.

An adequate medical surveillance program combined with reasonable dust control and good work practices can prevent new cases of chronic obstructive byssinosis and progress of existing acute byssinotic reaction as a problem among the textile worker population. Dust control alone cannot eliminate the problem. Emphasis in terms of energy and money should be toward solving the problem. The problem is byssinosis, not simply dust. If the emphasis on dust is too great, that on byssinosis will be too small. Byssinosis has been recognized in this country for long enough so the problems associated with it should not be put aside while arguments about dust continue. A realistically achievable level should be chosen, complied with, and the medical problem, which will be a continuing one, successfully met.

EXHIBIT NO. 43

Annual Cotton Dust Survey

Summary 1976

Brighton Plant

Location	Material	mg/m³ Respirable	mg/m³ Total
OPENING #1	Cotton	0.68	0.45
OPENING #2	Synthetic	0.31	0.53
OPENING #3	Synthetic	1.91	4.00
PICKING #1	Cotton	0.86	1.24
PICKING #2	Synthetic	0.24	0.34
PICKING #3	Cotton	0.12	0.28
CARDING #1	Synthetic	0.18	0.32
CARDING #2	Synthetic	0.16	0.32
CARDING #3	Cotton	0.64	1.34
CARDING #4	Synthetic	0.20	0.52
CARDING #5	Synthetic	0.30	0.44
DRAWING #1	Blend	0.16	0.46
DRAWING #2	Blend	0.23	1.01
DRAWING #3	Blend	0.27	0.57
DRAWING #4	Blend	0.50	0.60
COMBING #1	Blend	0.70	0.55
COMBING #2	Blend	0.30	0.30
ROVING #1	Blend	0.28	0.34
ROVING #2	Blend	0.22	0.41
ROVING #3	Blend	0.12	0.34
SPINNING #1	Blend	0.17	0.45
SPINNING #2	Blend	0.16	0.45
WINDING	Blend	0.18	0.46
TWISTING	Blend	0.25	0.41
SPOOLING	Blend	0.26	0.29
WASTEHOUSE		0.30	0.38

Annual Cotton Dust Survey
Summary 1976

Clinchfield Plant

Location	Material	Respirable mg/m³ 1975	Respirable mg/m³ 1976	Total mg/m³ 1975	Total mg/m³ 1976
OPENING #1	All Cotton	1.16	0.76	2.04	1.17
OPENING #2	Cotton and Synthetic	0.91	0.58	1.32	0.58
PICKING	Cotton and Synthetic	0.25	0.16	0.36	0.24
CARDING	Cotton and Synthetic	0.57	1.04	0.86	1.83
DRAWING	Blend	0.39	0.34	0.48	0.65
COMBING	Blend	0.72	0.48	0.85	0.69
ROVING	Blend	0.10	0.11	0.46	0.34
SPINNING	Blend	0.07	0.17	0.27	0.42
SPOOLING	Blend	0.17	0.27	0.18	0.34
WASTEHOUSE		0.37	0.38	1.20	0.62

There was a survey made November, 1975, and this was a supplementary survey for the University of West Virginia Pulmonary study.

EXHIBIT 47b

Supplemental Submission to Statement and Testimony of Harold R. Imbus, M.D., Sc.D. Medical Director Burlington Industries, Inc.

The data and information contained herein is made as a supplement to the oral testimony given at the hearings on the Proposed Cotton Dust Standard on April 22 and 25, 1977 (Transcript, pp. 1844-1954), to the written statement submitted on April 1, 1977 (Exhibit No. 47) for the record as part of the American Textile Manufacturers Institute, Inc., presentation, to the "Annual Cotton Dust Survey for 1976" (Exhibit No. 43) and to the "Appendix" (Exhibit No. 44) to the written statement.

In regard to the information concerning Exhibit No. 43, "Annual Cotton Dust Survey for 1976," the following is furnished:

1. The material or fibers being processed in the "distinct operation areas" at the Brighton and Clinchfield Plants are shown in Attachment "A" which is attached to this Supplemental Submission and should be made part of Exhibit No. 43.
2. Blending of cotton and synthetic fibers is done at both the Brighton and Clinchfield Plants at the drawing operation.
3. No dust level measurements or samples were made in the Weaverooms at either the Brighton or Clinchfield Plants at the time of the study by Dr. W. K. C. Morgan (Exhibit No. 39) on January 11, 12, and 19, 1976.

4. There are no weaving operations at the Ranlo Plant.

5. All dust level measurements or dust sampling at both plants was done by vertical eleutriators.

6. The dust level measurements shown for each "Location" at both the Brighton and Clinchfield Plants are *mean* or average dust levels.

7. The "Location," e.g. Carding #1, shown for the Brighton Plant are "distinct operational areas." The "Locations" are *not* sampling sites. Any attempt to determine mean or median dust levels from the information shown in Exhibit No. 43 is improper, would be totally misleading and completely in error.

8. Opening Location #1 at the Clinchfield Plant processes 100% cotton. Opening Location #2 at the Clinchfield Plant processes, within its confines, both cotton *and* synthetic fibers. The Picking Location at the Clinchfield Plant processes, within its confines, both cotton *and* synthetic fibers.

9. During the period of and prior to the study by Dr. Morgan (Exhibit No. 39), the cotton processed at the Clinchfield Plant was MCSLL, 1-1/16" Memphis and 1-3/32" California.

10. No significant engineering or product changes occurred during the period from 1970 through the date of the study by Dr. Morgan (Exhibit No. 39).

In regard to Exhibit No. 44, attached hereto as Attachment "B" are revised Tables I to IV, inclusive, which reflect *revisions in the calculations* of the information furnished to the American Textile Manufacturers Institute, Inc. by various companies regarding the results of the administration of the questionnaires and the pulmonary function tests in the companies' initial surveys of

employees. The information furnished to the American Textile Manufacturers Institute, Inc. remain unchanged.

Tables I to IV, inclusive, of Attachment "B" should be substituted for the corresponding tables presently in the record as Exhibit No. 44 and the tables presently in the record deleted therefrom.

In view of the revision of the Tables I to IV, inclusive, of Exhibit No. 44 as set forth in Attachment "B" attached hereto, Table II of the written statement, (Exhibit No. 47) has been revised. The revision in Table II of Exhibit No. 47 is attached hereto as Attachment "C". Attachment "C" should also be substituted in the official record in Exhibit No. 47 and the Table II presently contained therein deleted in its entirety.

Information requested in regard to the dust levels at Plant E, Table IV of the submission to Cotton Dust, Proceedings of a Topical Symposium, November 12, 13, 1974, Atlanta, Georgia, entitled "Experience with Medical Surveillance Programs" (Reference No. 57, Fed.Reg. Vol. 41, No. 250, Tuesday, December 28, 1976, p. 56514) is set forth in Attachment "D" which is attached hereto and made a part hereof. All dust level measurements shown in Attachment "D" are measurements obtained by the use of a vertical eleutriator.

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EXHIBIT 48

Statement of M. C. Battigelli, M.D.

* * * * *

The central point of equivocation in the OSHA document of December 28, 1976, as well as in several of the evidentiary publications quoted therein, resides in the inadequate criteria of diagnosis of byssinosis. Allow me to state that diagnosis, in medical practice, is the process of recognizing health states and health outcomes in order to define pathological processes, as precisely as possible, for the purpose of medical management and care. In order to assure a minimum of consistency and accuracy, methods of diagnosis require a great deal of uniformity in the application of identification criteria. Epidemiological surveys are not exempted from following rigorously these same procedures and criteria. A diagnosis actually consists of three consecutive and interdependent phases: the gathering of facts (i.e. history, examination, and laboratory tests), the assessments of relative importance and mutual relationships of these facts (diagnostic analysis and interpretation), and finally, distinguishing the correct entity from other diagnostic entities which are similar but not applicable (differential diagnosis).

In the specific example of byssinosis, the entire evidence (the fact, if you wish) is based on a symptoms-complex whose initial history has been clearly captured and unequivocally recorded in over a century of medical literature. The peculiar cyclic behavior of the symptom-complex is that it is present on a given day and it is not on the following day, in spite of identical environmental conditions. Although this is the evidence accepted by all experts in the field, it is only inadequately spelled out in the OSHA document. It should be clearly emphasized that any shortcut in the diagnosis of byssinosis will only

confuse the issue and vastly reduce the value of any measurement obtained on this faulty base. The proof that this occurs is readily provided by the evidence quoted in the OSHA document. When modifications of the Medical Research Council questionnaire are applied, diagnostic precision is seriously reduced, as for example, when critical questions are omitted, such as the omission in the OSHA document of number 8 of the original text [9]: "Do you get this (i.e. tightness or breathlessness) apart from colds?"; and number 10: "Has your chest ever been tight or your breathing difficult on any particular days? If yes, specify: First day back at work only versus other day(s) also."

These questions need to be applied and evaluated diligently, avoiding both omission and stereotyped interpretation. We are dealing here with facts of medical history, complex and crucial information. Any omission of adequate prudence may result in error. Coarser errors may be further encountered in the substitution of a tested questionnaire with a new and untested one where totally arbitrary elements of medical history are introduced, such as inquiring into the presentation of symptoms in a totally different context, and by eliciting complaints related to a pause of a week or ten days, an event, which is not normal on an annual or other basis and of an entirely different connotation and meaning. In this latter regard it must be emphasized that, although questions to elicit complaints related to a pause of a week or ten days have never been contained in any of the different editions of the Medical Research Council questionnaire, such questions are an integral part of Appendix A to the OSHA proposed standard. Reliance on and utilization of such questions can only lead to distortion of medical history and a failure to crystallize the diagnosis. When diagnostic criteria are violated, not only phase one (fact collection), but also phase two (analysis of data and inter-

pretation) and phase three (differential diagnosis) are affected and profoundly biased. The claim introduced in the OSHA document of concurrence of chronic bronchitis, asthma, emphysema, and other non-specific disorders have not been claimed or proven by any study or reports to be the consequence of cotton dust exposure. Similarly, chronic bronchitis has not been demonstrated by any persuasive published report to be either the consequence of or aggravation from cotton dust exposure.

It is indeed readily understandable that the uninformed public may mistakenly trace the cause of common respiratory complaints and difficulties to a factor which has received widespread notoriety, namely cotton dust. In fact, it is not unusual that patients are referred to the specialist's attention, with the putative diagnosis of byssinosis, are actually textile workers involved in operations *not* exposing them to cotton, a most persuasive evidence of this error.

In many studies published the definition of byssinosis presented is arbitrary and imprecise. This occurs when this definition, in fact, is obtained, operationally, through the use of a questionnaire, applied in the course of oversimplified interviews of textile workers. In one of these studies, the following questions were asked [10]:

1. Have you in the past, or do you now, develop a cough at work? (4 points if answer is affirmative and Monday or early part of the week is identified as the specific time of occurence).

2. Have you in the past or do you now develop a tight feeling in your chest while at work? (8 points, as per question 1).

3. Have you in the past or do you now become short of breath at work? (8 points, as per question 1).

4. Is your breathing better when you are away from work? (2 points).

5. Have you in the past or do you now have trouble breathing normally at the beginning of the workweek but find that your breathing improves as the week goes on? (6 points if positive).

Presumptively, in this study a diagnosis of byssinosis is obtained with this instrument automatically, with any score yielding a value of two or better. This can be done with a positive reply to Question 1 and that question only, or to any other question and that question alone. It is obvious that these questions have a much different meanning, weight, and liability to error. Admittedly, a positive reply to Questions 1 through 3 can be obtained from anyone with a history of a single episode (i.e. angina, pneumonia, acute bronchitis, etc.), totally unrelated to byssinosis. There is no differentiation between an episodic occurrence and a more persistent event. There is no evidence in the text of this paper toward attempts to minimize or exclude false positive replies. Question 4 may elicit a positive reply, in turn translated into evidence of byssinosis automatically, when the subject meant dyspnea on exercise or effort. It is a common experience that activity during weekend pauses are, in intensity or perception, lighter and more compatible with feelings of well-being than those faced during the working schedule.

Berry et al. [11] are probably responsible for a similar error, consequence of a faulty interpretation of a questionnaire. Their diagnostic matrix reads as follows:

Byssinosis 1: chest tightness and/or difficulty in breathing on Monday only.

Byssinosis 2: chest tightness and/or difficulty in breathing on Mondays and other days.

The definition of Byssinosis 2 is not adequately incorporated in this formulation. It should rather and unequivocally include historical evidence of Byssinosis 1,

that is, that recurrent difficulty experienced on the first day of exposure, usually disappearing on the following days (none on Tuesday). By the repeated assertions of all the authorities in the field, we understand that this historical evidence is the only characteristic available for this disorder. If this characteristic is neglected, byssinosis would lose any validity as a diagnostic entity or as a goal of diagnostic effort. There is little doubt that these errors have extensively biased the statistical results of several reports.

* * * * *

In summary, estimates of byssinosis prevalence require careful and systematic application of the orthodox definition of the disorder and shortcuts or oversimplification in diagnostic inquiry may result in colossal errors. This unfortunate consequence seems to have occurred in some of the surveys which understandably have received popular recognition. These errors should be avoided, lest the uninformed public, the patient population included, be misled into interpretation and decisions which are unwarranted, possibly becoming a threat to their livelihood.

EXHIBIT 54

"Burlington Industries Took Our Breath Away: Brown Lung Victims Tell Their Stories"

Mrs. Eva Bradshaw

April, 1977.

My name is Eva Bradshaw. I am 61 years old and I worked for 41 years as a spinner in Burlington Industries' Erwin Mills until I had to come out disabled with my lungs at the age of 55.

I want to talk some today about my medical experience and how the company and their doctor Battigelli has done me and then I want to talk about what the mill was like where I worked in the spinning room.

Along about 5 or 10 years before I had to come out of the mill my chest would get so tight it felt just like an accordian that had closed down, like it was squeezed shut as tight as it would go. I coughed all the time, especially at work. And I finally got so short of breath that I couldn't hold out to teach Sunday School that I had taught for 42 years.

The last few years I worked I had about coughed out my stomach lining and I developed a hernia from it. In fact, I had 5 major operations in three years and my doctor said every one of them was coming from that bad cough that I had.

In 1970 it got so bad at work that I couldn't even talk. I have never smoked in my whole life, so I figured it was my heart, this pain in my chest and having a hard time breathing. So I went to a chest specialist in Fayetteville. I never thought that would be the last day I would work; I thought I had ten more years.

She put me in the hospital for 9 days and she told me never to go back in that mill that it had already done me enough harm. She wrote on a paper that "byssinosis was probably present after 41 years in atmosphere of cotton dust."

I didn't know what byssinosis was. Nobody at the mill had ever talked about it and nobody ever told us that cotton dust was bad for us or it could cause a lung disease.

When I put in for my leave at the mill, they sent me a paper to go to Dr. Battigelli in Chapel Hill. He ran me through 3 days of testing and at the end all he said was 'that he couldn't pinpoint it to byssinosis.' And that was the last thing I ever heard about it for six more years, until the Brown Lung Association started educating us about it. I never saw a report from that doctor, the company doctor never talked to me or told me anything.

But just to show how far off that Doctor Battigelli is, I want to tell you what he wrote in my medical record, which I saw for the first time a few months ago when my lawyer got it.

First all he said I was a 65 year old woman, but I was only 55 when he saw me. Then here's how he wrote up my record, to show he had his mind made up: "the patient underwent extensive pulmonary testing *to rule out the possibility of byssinosis.* The pulmonary function tests *are not available* at this dictation." He said he was testing me to *rule out* brown lung, not to see if I had it. And then he didn't even have my test results when he wrote up the report. I guess he didn't need them because he had already made his mind up.

My husband worked in a cotton mill too, for over 50 years and in 1972 he had to come out too. The doctor then said he had "obstructive lung disease, probable bys-

sinosis." But before he ever knew what byssinosis was or even knew about his rights to compensation he died. The last few months of his life he just lived on an oxygen machine and the company told us nothing.

I don't think now that they should be allowed or trusted to educate mill workers about the dust because they won't tell people like they should.

* * * * *

Elsie Temple Morrison

April, 1977

My name is Elsie T. Morrison. I am 51 years old and I worked as a spinner in Erwin-Burlington Mills for 27 years. I'm not able to come and testify because I just got out of the hospital on account of my lungs and breathing.

But I want to tell some things that have happened to me at Burlington mills on account of the cotton dust.

In 1974 I was having to miss a lot of work because of my breathing and finally my doctor put me in the hospital for a week and sent a note to the company to have further tests, that I might have byssinosis. That was probably the first I had ever heard about brown lung. Before they sent me to Dr. Battigelli, my supervisor came and asked me did I want to bid on a job out of the dust. He said the company nurse had come and talked to him about me and said maybe I should get out of the dust since my "breathing had steadily declined over the years."

That kind of upset me, because she had never told *me* my breathing had been going down every year. I took the breathing tests since 1971, sometimes several times a year, and *they never told me anything.* They never said what my breathing was, if it was getting worse, or anything.

Instead of transferring me, they made me bid on a job in the cloth house. I took a pay cut of about $50.00 a week, because I had been making production before. I got to the cloth house, but the fumes in there made it just as hard for me to breathe, so I went back to my spinning job.

Then I got sick again and my doctor had me stay out of work. I was sending my doctor form to the mill every week until I found out they had put me on a year duration leave of absence. They never told *me* that before. At the end of that year, April, 1975, the mill insurance company (Provident) sent me a paper saying I was retired by the mill, *"totally and perm. disabled."* is just the way it read. When I tried to get some disability, because I couldn't work and I had to eat, they turned me down and said I was able to work. So I went to the Unemployment and when they got a statement from the mill they turned around and wrote I had *"voluntarily quit."*

For the last *two years* I have been trying to get some money to live on, and just getting the run-around wherever I go. I have lost *15 years worth of wages* by being disabled to work from my breathing, and the mill hasn't helped me get a thing. They take better care of their machines than their workers.

The mill *never* educated us about the cotton dust. They would call us in and show us movies sometimes about their profits and how good they was doing, and I remember they showed us a film about the earplugs, but they never said the dust was bad for us.

When they started giving the breathing tests in 1971, they never said why they was giving it. Our supervisors just said to come in early one time, that they would give us some tests before we started to work that day. Naturally, rumors got around; some people said it was for TB and some said it was the dust. But the mill

never told us what it was for or how bad off we were, so it died out after a while.

When I left the mill, the company doctor called me in. He said I had bronchitis, and he layed it to smoking, and he went on a lot about my heart being bad and a artery being enlarged. Funny, when I was trying to get my disability, none of the other doctors said there was anything wrong with my heart.

That Dr. Battigelli never sent me a report, but I got it from my doctor, and Battigelli said, "She does not present *convincing* cyclic disorder which would allow diagnosis of byssinosis." What did he think I was doing, lying? Since I know now what I didn't know then about how they tell if its brown lung, I think that doctor tricked me. He asked me a bunch of questions, and I told him my chest was tight and my breathing was worse when I went back to work on Sunday night. But he asked me if I felt worse at the beginning or the end of the week, naturally I figured I felt worse at the end of the week; I was give out from working all week. It had got to where my breathing was bad all the time and it was hard for me to hold out.

My breathing is better since I've been out of the mill, but where does that leave me? I got nothing to live on, no pension, no nothing. And I've give that mill the best part of my life and work.

Gilbert Stone

* * * * *

When they started giving us the breathing tests at the mill, they didn't say nothing about the cotton dust, no details, they just said they wanted to check our breathing for our own benefit. But they never told us why, or what we were taking it for. People complained about having to take it and blow, but everybody did it anyways. Some people that blowed so hard had their noses bleed.

* * * * *

Linnie Mae Bass

April, 1977

* * * * *

Since we are the last group of brown lung victims to talk, we want to try to tie together what all the rest of our members have been testifying about. And the two most important things I want to emphasize are this: *The companies can not be trusted to do their own educating, and they can't be trusted to do their own medical testing and tell us the true results.*

You have heard testimony over and over from our people about how the companies never educated them about the cotton dust and never told them the results of their breathing tests. Well, Burlington never told me mine either.

* * * * *

Hubert Graves

April, 1977

My name is Hubert Graves. I worked 22 years as a bobbin man in the spooling and warping department of Erwin (Burlington) mills. I was forced to come out of the mill on pulmonary disability at age 54, back in 1974. I didn't plan it that way; I thought I had 10 or 11 more years to work when I was 54, but I just couldn't hold out.

I don't think the companies should be allowed to measure the dust in the mills because I don't think they'll do it right. When I worked there, when they measured the dust in the spooling department, they put that machine at the end of the spoolers, nearest the air conditioning vent. They didn't put it in the middle.

Besides being a bobbin man, I spent the better part of 12 years blowing off the dust every Saturday or Sunday. We just spent the whole day, me and two other

clean up hands, just blowing the dust down and sweeping it up. And that dust was just a-flying and a-fogging everywhere. We blowed across the machines in each other's faces and blowed it down from the ceiling in our faces and all over us. But the company never told me it was bad for me, and they never told me to wear a mask or nothing. The just had us wear safety glasses or goggles, but they never said nothing about masks. Up to 1974 when I come out, I never saw a mask in Erwin Mill.

That dust put me out of work, 10 years before my time. About 1965 I started getting short of breath and got to coughing all the time. I kept on working and it kept on getting worse. The last few years I worked I'd have to miss right smart of work. I was in and out of the hospital so many times, I can't even remember how many times.

My doctor he kept trying new pills and medicine 'till he finally said he'd give me everything he knew to treat me, and the only thing he knew was for me to get a transfer to another part of the mill. But the mill kept saying there weren't no jobs to transfer to, even though they knew I was bad off. They said one time, "If you aren't able to run your job we'll have to replace you.

My doctor finally said I should get out altogether. That it was shortening my life everyday that I was in there.

But I knew that I had to go to work. I had 3 kids at home to support and I just went back and kept on trying. I finally just collapsed on my job and didn't ever go back. I got my disability at age 54, not able to work anymore and support my family.

My point in telling my story is this: the company never educated us about the effects of the dust, even though they knew, and I don't think that they will do

it right, even now. When they started the breathing tests, they never told us what it was for and we never knew, and they never told us what we scored. The company let me work overtime every weekend cleaning up that cotton dust but they never told me it was bad for my lungs or never gave me a mask to wear. They wouldn't even transfer me out of the dust when my family doctor wanted it. They just want to make money and they don't want to be bothered with sick workers.

I think that the companies have done us and our people enough harm already and they shouldn't be allowed to do no more.

Not for seven more years.

* * * * *

William R. Tyndall

April, 1977.

My name is William Tyndall. I am 66 years old now and I've been disabled by brown lung disease since I had to come out of the mill at the age of 59 in 1970. I was a doffer in the spinning room of Burlington Industries' Erwin Mills for 35 years.

I said I've been disabled by brown lung disease for 7 years, but I should say that I only found out I had byssinosis this year when I filed for compensation and got sent to a doctor who could tell me what it was.

I started being bothered by shortness of breath back in 1962. After a while, I went to Dr. Adair who was the company doctor. He said that I had emphysema and he might have to take me out of the mills. I knew I had to keep working to survive, so I kept on running my job for a couple of more years. When it started getting to where I just couldn't hold out to run my job, I went back to Dr. Adair, but then he wouldn't say nothing about me quitting work. Sc, I went to another doctor who advised me to get out of the mill.

I knew something was wrong, because I couldn't hold out on my job. But I didn't know what, so I took a temporary lay-off until a job would come open that I thought I could hold out to run. To show you how dirty they'll do you, the company tried to fight me getting unemployment. I was a good doffer and they didn't want to lose me. They said that they had a job I could run when they knew I couldn't run it. But the unemployment ruled in my favor.

As soon as a job came open that I thought I could run, I went back to the mill. I worked for six weeks at this job, and it was a 90¢ per hour wage cut, but I just couldn't hold out. My doctor helped me get disability. Nothing else has ever been wrong with me except my breathing and this lung disease.

Where I worked I know a whole lot of people have had to come out early because of breathing problems. I've seen several people collapse of their jobs and some who were just carried out on stretchers. A lot of them that would be my age and that I grew up with, are now dead.

I know a lot of millworkers would keep on working when they weren't able because they had to work to survive and had no other choice. As long as they could run their jobs, the company didn't care how bad off they were. The companies are mainly concerned with keeping production up and keeping the machines running. They care alot more about their machines than they do about their employees.

Most of what they did before I came out has tended to make the problem even worse. The windows were bricked up. Automatic sweepers and cleaners were put in, which kept the lint and dust fogging up. All of these were money saving projects. Now it's about time they spent some money reducing the dust levels and not wait for seven more years.

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EXHIBIT 54a

Statement of Carolina Brown Lung Association

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D. *RESPIRATOR USE*

OSHA has proposed that when engineering and work practice controls have not reduced dust levels to the proposed .2 mg/m^3 standard, then the employer shall "provide and assure the use of" respirators. This clause, together with the proposed delay of 7 years in meeting the standard, ignores the fact that the employee is, in effect, being punished because the employer has been negligent in complying with the OSHA law. Carolina Brown Lung Association members are very familiar with the harsh discomfort, exasperating annoyance, and in some cases, agony, of wearing respirators while working, even for brief periods of time. To suggest that this could be done day-in and day-out for 7 years simply shows that the proposal writers have never worn respirators. The respirator does not provide the user with a cool, effortless stream of fresh air, as some would imagine. Breathing through one is extremely hot, and often difficult or impossible when the dust has clogged the filter pores, especially for those with existing respiratory problems.

The proposal also does not address the fact that, for some individuals, any given (and in some cases, many) respirators may not fit properly. Since respirators are designed for an "average employee", women, and employees with sideburns, scars, glasses, or merely slightly different facial shapes are often not afforded equal protection by respirator use. It must be recognized that some employees with certain preexisting health problems, such as heart conditions, should not wear respirators. There is also no mention of the fact that wearing respirators will in some cases lower production capabili-

ties of workers. Fatigue and reduced efficiency occur more quickly among workers wearing respirators; those on piece-rate wage scales may suffer wage loss as a consequence.

The Carolina Brown Lung Association believes that:

1) the textile industry should be required to meet a .1 mg/m^3 standard now.
2) where respirators must be used, employees should be given a choice from a wide variety of respirators, including the single use respirator, and the powered respirator.
3) the standard must disallow any company requirement that an employee who refuses to wear a mask must sign a statement limiting the company's liability.
4) employees must be protected from economic losses occurring as a consequence of wearing respirators.
5) those employees with health conditions which preclude the use of respirators must be given the option of transfer to a less dusty area with no loss of pay or seniority.

E. *MEDICAL SURVEILLANCE*

OSHA's proposal for a medical surveillance program for textile industry employees emphasizes a rigorously "scientific" screening of those workers at risk, but ignore some basic realities of management/employee relations in this predominantely non-union industry in the South.

The personal experience of many Carolina Brown Lung Association members is that a medical surveillance program without a job/rate retention clause is virtually meaningless. Even if one were to assume that OSHA's proposed dust control measures were *immediately* implemented, there would be no job protection for the thou-

sands of active workers who now have some stage of byssinosis. Many CBLA members, when the disease they had contracted in the mills became severe enough so that they could not work "productively", were simply asked to leave—often after having been told by the company doctor that they had bronchitis or emphysema, and often with their pensions slashed, since they had had to "quit" early. CBLA members believe that there is no reason to expect a drastic change in management behavior, and that the first requirement of a medical surveillance program would be a clause giving the worker the right to transfer with no economic discrimination.

The mechanics of the program which OSHA has proposed also ignores the basic nature of the relationship between company doctors and the mills for which they work. OSHA proposes that any doctor of the company's choice will conduct the medical surveillance program (restricted only by very broad guidelines), will determine, for each worker, whether specific findings or diagnoses are related to occupational exposure, and will give an opinion as to whether the employee's exposure to cotton dust should be limited. The experience of many CBLA members with their company doctors suggests that OSHA's trust in these doctors' objectivity is misplaced. CBLA members have been told for years by company doctors that their respiratory problems were bronchitis, emphysema, asthma, "caused by smoking",—or simply not told anything at all about their medical conditions. Given the fact that diagnosis of initial stages of byssinosis is based on subjective interpretations of subjective responses to a questionnaire, allowing a company doctor to determine whether a disease is occupationally related would only perpetuate a system which has blatantly neglected disease victims.

The Carolina Brown Lung Association believes:

1) that medical personnel conducting the medical surveillance program must be independent—not be an

employee of any employer covered by the standard, nor have any financial relationship other than as recipient of fees for examinations.

2) that data generated by medical examinations should be sent to NIOSH where analysis according to the "standing diagnostic criteria" (discussed below) would be carried out. An employee would be sent the results of such tests together with an explanation of his right to transfer and to other measures designed to protect his health.

3) that, in order to protect the employee, NIOSH should produce a program of "standing diagnostic criteria" which would determine those medical and administrative measures available for a given medical examination result. We support the proposals made by ACTWU in this regard, and suggest that this concept be extended to include a larger range of possible questionnaire and spirometry findings, thus closely defining what is a "significant change" in examination results, and the medical and administrative measures which would be dictated by each.

4) that not only physicians, but paramedical personnel could conduct medical surveillance programs.

5) that NIOSH should institute a quality control program to review the industry's medical surveillance activities.

EXHIBIT 55

Statement of Moon W. Suh, Ph.D. Senior Operations Research Analyst, Burlington Industries, Inc.

I am Dr. Moon W. Suh, Senior Operations Research Analyst of Burlington Industries. I am a professional statistician with a Doctor of Philosophy degree in Statistics from North Carolina State University. During the last seven years, I have been responsible for analyzing all biomedical data of Burlington Industries which include byssinosis prevalence, pulmonary function, and level of dust exposure for thousands of employees working in the cotton processing areas of the Company. I have conducted numerous statistical studies on byssinosis as well as on cotton dust, of which much has been published in scientific journals. Accordingly, I testify as one of few research statisticians who has worked extensively on the perplexing issues of byssinosis.

To begin, I must point out that the entire byssinosis issue still remains to be only a statistical paradox in the complete absence of any definitive science on the diagnosis and pathogenesis or proven knowledge of the responsible chemical components. Indeed, we are still playing the game of numbers based strictly on isolated incidences or yet-to-be-found laws of probability at best. Despite all this, we now have a proposed cotton dust standard based solely on scattered statistical figures that are dangerously biased and insufficient for the awesome purpose of legislating a federal standard.

Specifically, I will point out the fallacy of one statistical study which has been responsible for the proposition of a 0.2 mg/m^3 dust standard. Following this, I will show entirely different results from a study made by Burlington Industries which we consider to be unbiased in population selection and statistically sound in model

selection and analysis. The wide disparity between the two studies will exemplify the fragile foundation for the proposed 0.2 mg/m^3 dust standard.

The background argument for the proposed OSHA cotton dust standards draws inferences heavily from a study published by Merchant and others[8] in the Journal of Occupational Medicine in 1973 titled "Dose-Response Studies in Cotton Textile Workers." The so-called "probit analysis" shown in the study, which I will call "the Merchant study" from here on, projects byssinosis prevalences at 0.1, 0.2 and 0.5 mg/m^3 respirable cotton dust to be 6.5, 12.7 and 25.8%, respectively, for workers in preparation and yarn areas. The authors, then, proceed to recomemnd 0.1 mg/m^3 as a "reasonably safe" dust level implying, perhaps, that a 6.5% byssinosis prevalence is a reasonably safe risk. Since there does not exist another dose-response study of any type for predicting byssinosis prevalence directly from dust levels, as measured by a vertical elutriator, it is safely assumed that the proposed 0.2 mg/m^3 standard stems from this study. The study, however, is considered totally unfit and inadequate for being applied to formulation of a federal standard in view of its definite biases and errors in study design, statistical analysis and conclusions. The reasoning is as follows:

1) BIASES IN STUDY DESIGN

For a general prediction purpose, it is a norm to any statistical study that the sample population should be representative of the parent (total) population. In order to accomplish this, a rigid randomization scheme has to be applied in the sample selection process. The Merchant study, however, does not meet this. As they report in their study [6 (pp 93-94), 7], two of the five cotton and cotton/synthetic plants were at "extremes of exposure," meaning that the plants were old and processing

worst quality cottons. The remaining three, although not stated explicitly in the paper, also belonged to the same category. The plants seem to have been so selected to maximize the chances for observing a large number of employees with symptoms of byssinosis. This is evidenced from data reported in the study itself on employee length of exposure. The data shows [7, Tables 1 and 2] that as much as 53% of all employees in cotton and blend mills had been exposed to cotton dust for more than 15 years whereas only 16% had worked for that many years or more in the control plants processing synthetic or wool. Moreover, as many as 36% of all employees in cotton and blend mills worked over 25 years while only 4% of all employees in control plants worked over 25 years. These statistics are staggering and such bias alone guarantees a highest possible prevalence of the symptoms of byssinosis as defined by questionnaire without regard to the level of cotton dust they were exposed to at the time of survey. In addition, the authors required the cotton plants for the study to be located within a textile mill village, thus further increasing the chances for continuous and prolonged employee exposure to dusty environment. More importantly, the cotton processed in the selected plants was mostly "strict low middling" which is a low grade cotton known to contain as much as 5.1% non-lint materials according to a book by Grover and Hamby[2]. All these unusual, non-representative factors in the Merchant study were responsible for observing as high as 19.2% byssinotics in cotton plants and 8.2% in blend mills. In a published 1971 Burlington study[3] using over 10,000 sample subjects, or more than 5.5 times the number surveyed by Merchant and others, the average prevalence was only 5.2% at cotton plants and 4.4% in cotton/synthetic blend mills. These amount to only less than one third and about half of the corresponding prevalences found from the Merchant study. The large differences are not from random errors of survey. Instead, the differences are almost entirely due

to the systematic biases clearly demonstrated in the Merchant study.

Most importantly, the sample size of 1,271 in preparation and yarn areas was simply too small to represent the entire textile population, especially for predicting prevalences at every possible dust level below 1 mg/m^3. Consequently, such important variables as sex ratio, age, % smokers and length of exposure were surveyed but could not be taken into account in establishing the so-called "dose-response" relation.

In summary, Merchant study does not represent the cross-sectional average of textile population exposed to cotton dust. The proof for this is evident from the demonstrated biases in study design, the insignificant sample size and deletion of all relevant statistical factors essential for establishing an acceptable dose-response relation.

2) BIASES IN STATISTICAL ANALYSIS

It seems rather pointless to argue the quality of analyses when the basic design is already shown to be totally biased. Nevertheless, I am compelled to point out the serious biases and errors of statistical analyses contained in the study. If we are to talk about numbers and the limits as criteria of importance, the following points should raise serious questions on the validity of the proposed standard.

A. "*Probit Model*"—The fact that probit model is inappropriate can be established by examining the underlying binomial assumptions and the reported data. First, the symptomatic response of byssinosis is not a quantal measure such as "dead or alive" type of response normally found in toxicity studies. Instead, the byssinotic response is highly subjective, as it is nothing more than a positive response to a question, and involves large

statistical errors. Second, more often than not, a given subject had been exposed to varying levels of cotton dust prior to the time of survey, and this wipes out the independence assumption governing the binomial distribution. In his book *Probit Analysis*, Finney [1, p 27] states: "The complete independence of the subjects tested at different doses, and of the binomial distributions associated with them, is implicit in the theory of all the methods presented in this book." In this regard, there is no better way to invalidate the use of a probit analysis than the following statement made, perhaps inadvertently, by Merchant [6, p 103] on his own analysis:

> "—it must be stressed that the cross-sectional nature of this study indicates that the *probability* (of byssinosis) *determined in these analyses is the probability that a subject has the disease at the time of observation, rather than the probability of developing the disease.*

What better statement than this to disqualify the probit model! Third, as the authors admit in their paper [8, p 228], the data shown in Table 4 of the study clearly demonstrate the fact that byssinosis prevalence is *not* zero at zero dust level. This is another proof that the probit analysis applied in the Merchant study was totally inappropriate for the data.

Finally, the probit model, when combined with a logarithmic transformation of dust level, not only projects a zero prevalance but also a zero confidence limit at zero dust. In addition, it creates fictitiously narrow confidence limits at low dust levels regardless of the spread in actual prevalence data. All these are more than sufficient for invalidating the probit model and the con-

clusions therefrom. However, let us continue to examine the following.

B. *Grouping/Categorization of Data for Probit Analyses*—It is observed that the methods, if any, used for forming the basic sample points in Tables 3 and 4 of the paper are totally without logic. Any statistically minded researcher will know that a different grouping and categorization methods can create artifacts and therefore and absolute objectivity and unbiased rule must be applied in forming the basic sample points.

First, why categorize by dust levels in the first place at the sacrifice of sample size? Some merging might have been necessary for sample points with small number of employees. But, the grouping by dust level in Tables 3 and 4 was obviously improper in terms of obtaining the highest valid statistical correlation.

Second, it is impossible to understand how the authors came up with the end points of the dust ranges shown in Tables 3 and 4. The intervals are neither uniform in size nor varying with any consistency. Were the intervals and end points created by the observed data? If so, for what purposes?

Third, in Table 4, the "mid-points" of dust ranges were given in arithmetic mean for Groups 1, 2, and 4 and in geometric mean for Groups 3, 5 and 6. There is no justification for this inconsistency. It is a mathematical fact[5] that the geometric mean is always less than or at most equal to the arithmetic mean when the observations are non-negative. This can be seen in Table 1, where the arithmetic means are shown to be greater than geometric means by about 60%.

What does this mean? It means an unduly high predicted prevalence at every dust level by applying geometric means. It is not my ultimate intention to correct the bias using the average figure quoted above. The figures speak for themselves.

C. *Inflation of Prevalence Through Abuse of Median, Geometric Mean and Arithmetic Mean*—The original cotton dust data in Merchant study were given in medians which are strikingly lower than the corresponding arthmetic means. In Table 1 of the paper, the arithmetic means were shown to be higher than the medians by as much as 34.8% and 65.6% due to the extreme skewness in the dust distributions. Such magnitudes of skewness are quite unreal based on all existing statistical facts. In a 1974 study[9], the mean dust level in a carding area (0.977 mg/M^3)' was shown to be only 17.7% higher than the corresponding median (0.830 mg/M^3) based on 103 vertical elutriator samples. In a spinning room, however, the mean (0.439 mg/M^3) was only 2.1% greater than the median (0.430 mg/M^3) based on 87 samples. In other surveys[4] conducted by Burlington Industries in 1971-72, the mean was, on the average, only 5.3% higher than the corresponding median based on several hundred samples taken at 48 separate working areas.

In general, dust samples are positively skewed. Nevertheless, the degree of skewness is insufficient to negate a normal distribtuion assumption. Simply, arithmetic means cannot be greater than medians by as much as 50% on the average based on any other reported study. What does this mean in terms of the dose-response relationship? It

means that had means been used instead of medians, the projected prevalences of 6.5, 12.7 and 25.8% should occur *not* at 0.2, 0.2 and 0.5 mg/M^3 but at 0.15, 0.30 and 0.75 mg/M^3, namely at 50% higher dust levels instead. This effect, combined with the use of geometric mean in the probit analysis, creates the highest possible value of predicted prevalence at any hypothesized dust level. This type of statistical inference is certainly deplorable and particularly so for the purpose of applying to federal regulations.

D. *Exclusion of Sample Points*—The Merchant study excluded sample points with 1 mg/M^3 dust levels or higher in their analyses because "those exposed to these high dust levels were likely to be a select, more resistant group." To say the least, the assumption is completely without substantiation. In fact, this assumption was withdrawn in the analysis of workers in the slashing/weaving areas, areas where the prevalence was quite low. The study clearly shows that the subjects at the sample points with 1 mg/M^3 dust levels or higher are all males except one, 68.5% smokers and 40% black [8, Table 3]. All these factors indicate that the excluded employees constitute a less "resistant" group instead of being more "resistant."

E. *Computational Errors*—The published studies of Merchant and others show at least five different numbers of sample subjects for the same study according to Tables 1 and 2 of the dose-response study and Tables 1 and 3 of the preceding paper[7] by the same authors. It can be any one of 1,271, 1,257, 1,259, 1,318, or 1,237. Furthermore, there are numerous computational errors which question the accuracy of the reported data.

3) CONCLUSIONS ON MERCHANT STUDY

A. The dose-response study by Merchant and others had built-in biases in location and age of plants, length of exposure to cotton dust and quality of cotton processed. Consequently, the dose-response relationships as well as the projected byssinosis prevalences are totally biased and hence non-representative of the average textile population exposed to cotton dust.

B. The "probit" model and the resulting dose-response curves are totally inappropriate in view of both the underlying assumptions required by the model and the actual data observed. Therefore, the predicted prevalences and their confidence limits are totally invalid, particularly at low dust levels.

C. The methods used for grouping/categorizing original data in formulating sample points were unwarranted, inconsistent and least objective. Hence, the uniqueness of the conclusions is open to question.

D. Use of median and geometric mean, together with the extreme skewness present in dust distributions, forced the projected prevalences to be the highest of all at all dust levels. The magnitude of bias from this alone is sufficient to warrant a major correction in dose-response relation and an equivalent adjustment in the proposed cotton dust standard.

E. The logic applied for excluding sample points with 1 mg/M^3 or higher dust is without proof. This and other significant discrepancies in the tabulated data seriously challenge the credibility of the study.

F. Based on all above, the results of dose-response analyses by Merchant and others are considered totally unfit to be applied to formulation of federal cotton dust standards.

4) DOSE-RESPONSE STUDY BY BURLINGTON INDUSTRIES

Finally, I would like to present the results of a dose-response study made by Burlington utilizing 2,865 subjects. Leaving the details to the research report herein submitted as a supporting document, I will give only the highlights of the study.

The study utilized the first companywide byssinosis survey conducted in 1971. These virgin data were preferred over other subsequent survey results since they are free of possible bias due to repeated surveys. A total of 19 cotton and blend mills with 99 separate working areas provided 1,776 males and 1,089 females, or a total of 2,865 subjects. Mean dust levels, not the medians, were matched to the prevalence data for the 99 work areas. The cotton dust samples were taken by vertical elutriators with flow rate of 1.61 liters per minute.

Because of the large statistical errors inherent to the estimation of binominal probability, the work areas having small sample sizes were merged by applying a strict randomization scheme. Sample points were formed with minimum cut-off limits of 15, 20, 25 and 30 persons per point in an increasing order of dust level when merging was necessary. Any tie resulting from identical dust levels was broken by applying a pre-designated randomization scheme. Since different cut-off limits may exhibit different dose-response relations, all results were reported and compared.

The statistical model applied was a weighted least-squares method based on a square-root arc-sine transformation of percent prevalence. Under the model, the

transformed response variable becomes uniform in its asymptotic variance, thus satisfying the basic requirement for making a normal regression analysis.

The dose-response prediction equations were obtained for the combined total population of male and female with and without considering the smoking effects. Confidence limits were also obtained for the predicted prevalences. All prediction equations were found to be statistically significant, but the different cut-off limits for sample points did not yield any significant difference in the dose-response relations. Predicted prevalences of smokers were shown to be somewhat higher than non-smokers. The differences were statistically significant at 10% error level.

The predicted prevalences from the Burlington study were much lower than the corresponding values reported by the Merchant study. The large differences are definitely not from random variations but from the systematic biases of the Merchant study as previously discussed. The magnitudes of differences are as follows for the total population:

> At zero dust, the Merchant study projects zero prevalence due to the severe limitation in the "probit" model and not due to an absence of observed byssinotics. The Burlington study, on the other hand, projects 2.2% at zero dust. This may imply more than two out of 100 who have never been exposed to cotton dust can be incorrectly diagnosed as byssinotics or migration of byssinotics from high dust areas to areas with near-zero dust. At 0.1 mg, the Merchant study projects 6.5% byssinosis whereas only 2.8%, or less than half, is projected by the Burlington study. At 0.2 mg, the Merchant study predicts 12.7% or almost four times the 3.5% prevalence pro-

jected by the Burlington study. At 0.5 mg, the Burlington study predicts 6.0% while the Merchant study predicts a whopping 25.8%, or more than four times the Burlington figure. In short, 0.1 mg in the merchant study predicts even higher percentage of byssinotics than the Burlington estimate at 0.5 mg. Such a large gap is also apparent in another comparison. As Dr. Imbus will (has) discuss(ed) in his testimony, an industrywide survey of 41,283 subjects exposed to cotton dust revealed that the overall byssinosis prevalence at dust levels 0.5 mg/M^3 or higher was only 3.2% out of a total of 6,855 employees in that category. This is less than half of the prevalence the Merchant study projects at 0.1 mg. We need not develop another dose-response relation to prove the extreme bias in the Merchant study. The raw data is more than enough.

The Burlington study may not be the most ideal one for representing the entire textile population exposed to cotton dust. It simply proves the vulnerability of Merchant's results under a different set of population and analyses. Nevertheless, it is my honest view that the Burlington study has many improved features over the Merchant study; larger and more representative study population, unbiased plant selection, application of more appropriate model and complete absence of subjective data handling would be the key advantages.

In concluding my testimony, I must come back to my earlier criticism on the Merchant study. Simply put, *the study is completely invalid, statistically or otherwise, for the purpose of predicting the byssinosis prevalence of the average textile population from a hypothetical level of cotton dust.* The study may have proven an existence of correlation between the two. No more and no less. It

certainly failed to provide a reliable prediction equation. Should this type of study ever be applied in the formulation of a federal standard? The answer has to be definitely "No." What other scientific criterion, statistical or otherwise, then is there for promulgating 0.2, 0.35 or 0.5 mg/M^3 dust limits as measured by a vertical elutriator? I find very little evidence which supports such specific numerical figures. To this statistician, the standards appear to have been drawn from subjective criteria rather than an unambiguous goal scientifically established.

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EXHIBIT 60

Statement of Hovan Hocutt, Senior Vice President, Engineering Pneumafil Corporation Before the Public Hearing Concerning the Proposed Changes in the OSHA Cotton Dust Standard

My name is Hovan Hocutt. I have a Bachelor of Science degree in Aeronautical Engineering from North Carolina State University and I am a licensed Professional Engineer. I have 13 ½ years experience as factory engineer and officer of a woven asbestos brake lining factory where one of my responsibilities was the engineering control of asbestos dust. I am now Senior Vice President-Engineering of the Pneumafil Corporation, Charlotte, N.C. where I have been since 1950. Pneumafil Corporation was formed in 1946 to design and manufacture systems for the control of lint and dust in the textile yarn manufacturing industry. This has always been its primary business. We are in regular contact with leading manufacturers of cotton dust control systems in England, Germany, Switzerland, Hong Kong, Japan and other foreign countries.

In June of 1972, Pneumafil Engineers began work on NIOSH Contract HSM 99-72-44 to determine what engineering controls would be necessary to achieve a dust level of 0.5 mg/M^3 as measured by the vertical elutriator (VE) in the processing areas of opening, picking, carding, drawing and combing. Some investigation of dust capture devices and air quantities required to achieve 0.2 or 0.1mg/M^3 VE was also included.

The results of this research were published under the title "Cotton Dust Controls in Yarn Manufacturing", HEW Publication # 74-114 by NIOSH in March, 1974. This report described dust capture and filter equipment which could achieve dust levels of 0.5 mg/M^3 VE. En-

gineering controls that could hold the median dust concentration to a level not exceeding 0.2 mg/M³ VE in the working environment of drawing and combing processes were also described. Dust capture devices and air quantities necessary to achieve a median dust concentration of 0.2 mg/M³ VE in the carding environment were also described. However, the report pointed out that a practical application of fine dust filters which are efficient on particulate sizes of 15 microns or less had to be developed and added to existing engineering controls for achievement of of median dust concentration of 0.2mg/M³ in the areas of opening, picking, and carding. This report was widely distributed by NIOSH and I assume that those interested in this subject are familiar with this report. Therefore, I will not take the time here for a description of the technology involved.

I can report that there have been improvements in both efficiency and cost of engineering controls since publication of the report. For example, we have reduced air quantity requirements for opening and picker hopper covers by 50% and maximum air quantities for cards by 12.5%. These and other improvements have helped to offset some of the inflation in machinery prices.

After the NIOSH study, we, also made an analysis of existing filter technology and concluded that the most practical fine dust filter (less than 15 microns) for cotton dust control in opening, picking and carding areas would be two-stage, low voltage electrostatic precipitators, commonly called electronic air filters. Pneumafil Engineers conducted tests in an operating cotton mill card room with laboratory size electrostatic precipitators over a period of 3 years. Although we do not have any experience with production size equipment, we are confident that we know how to aply these fine dust filters to lint and dust control systems in opening, picking and carding areas in cotton mills.

Unfortunately, electrostatic precipitators specified at required efficiency would stand about 12′ high x 15′ wide and including transitions about 30′ long. They would weigh about 8,000 pounds for a system handling 50,000 cfm. Our experience indicates prefilters will have used up all of the available space inside the processing area and it will be necessary to install the precipitators outside the processing area in new buildings or in insulated enclosures on the roof of the mill.

Our cost data, to follow, for engineering controls to achieve a cotton dust level of 0.2 mg/M^3 VE $\overline{X}$ (average) in opening, picking and carding will include conventional dust capture devices on the production machines, a preseparator for removing the lint load from the primary airstream, automatic rotary drum filters, each of which are extremely large, in one or two stages to remove the coarse and medium dust and electrostatic precipitators to remove the fine dust. Electrostatic precipitators will not be required beyond carding.

At the request of ATMI, Pneumafil Engineers began an economic impact study covering engineering controls for cotton dust to achieve various cotton dust standards. This study is based on information provided by an ATMI questionnaire sent to all of its member mills. These questionnaires provided information by individual mill on numbers of bales of cotton processed, ratio of synthetics to cotton in blends, numbers of each type of cotton processing machinery by department such as opening, picking, carding, etc. Production speeds and other data affecting generation of cotton dust were also provided. Type of humidity and temperature controls for each process area and air conditioning filters were specified along with air change rates and the descriptions of air conditioning supply and return-air arrangements.

Completed questionnaires were returned by 369 mills. Relevant information was supplied by 353 mills (others

were not processing cotton or did not involve the relevant processes). The 353 mills processed 5,719,393 bales of cotton from August 1, 1973, through July 31, 1974. This was 80% of the 7,149,887 bales processed by the entire U.S. industry in the same period. Also these 353 mills accounted for 13,310,696 spinning spindles in place. This was 83% of the 16,056,978 spindles in place processing cotton or cotton synthetic blends in the entire U.S. textile industry.

All information concerning in-place air conditioning systems was tabulated from the questionnaires and given to Mr. Arthur Thomas of The Bahnson Company for use in estimating the cost of air conditioning systems required to absorb the added loads imposed by the lint and dust control equipment.

Tabulations were made of the total number of each type of cotton processing machinery with production rates and other pertinent information. Air quantities (cubic feet per minute) required for each type of processing machine to capture the cotton dust and the average cost of dust control equipment per cfm were added to these tabulations. Air quantities and equipment costs for opening, picking and carding were based on actual installations. For other processes, these figures were estimated from analysis of typical production units. From these tabulations gross total costs of engineering controls for each type of machine and each process was calculated. Gross total horsepower and cubic feet per minute of air (cfm) required for lint and dust control systems was also calculated and given to Mr. Arthur Thomas.

In addition to information provided by the questionnaire, additional dust sampling data was provided through ATMI from more than 70 mills. To this was added, for weave rooms, all qualified data secured from other sources and in the files of Pneumafil Corporation.

Total cfm, total installed horsepower, and total dollar figures were secured by ATMI from all significant lint and dust control systems contractors (SafeAire, Bahnson, Jenkins, Pneumafil). These figures included all engineering controls for cotton dust sold prior to February 11, 1977. The estimated dollar value of these controls (pre-February 11, 1977) was subtracted from our calculated gross cost figures for the industry. So, our estimate covers the industry's future burden *after* February 11, 1977. This point cannot be overemphasized.

Net totals were adjusted to represent totals for the entire textile industry in the U.S. on the basis that the study covered 80% of the industry (multiply ATMI data by 1.25). Annual maintenance and energy costs were estimated based on the same data. The cost which we will report includes all engineering, suction attachments on production machines, suction duct, insulation as required, separators, filters, #5 condensers, fans, drives, electrical and machine controls, all ducts required to connect the lint and dust control system to the air conditioning apparatus, exhaust and return air dampers with operating controls, fire detection and control devices for filters, equipment supports and roof reinforcement where required, hardware, installation ready to run, cutting, patching, electrical modifications, which the mill normally incurs, wiring, controls, and electrical service additions necessary for the lint and dust control systems. The costs are based on prices as of February 11, 1977. Any processes or operations not specifically mentioned are not included.

The costs do not include #6 condensers as required (they are usually on hand in the mills). Additional air-conditioning necessary to compensate for increases in horsepower loads required to operate lint and dust control systems, freight and taxes are not included.

Maintenance costs are based on 75% of an ideal maintenance program as suggested in the manufacturers' service manual. Labor rates were taken from "Employment and Earnings" published by U.S. Department of Labor (average hourly rate for a non-supervisory production worker is $3.53 per December, 1975-issue. Minimum rate of $2.30 per hour was used for helpers).

OPENING, PICKING AND CARDING AREAS

We have many years of experience with the engineering control of cotton dust in the processing areas of opening, picking and carding. We began to install lint and dust control systems in opening and picking rooms soon after the first of 1966. In February, 1972, we began to write performance warranties on these systems based on a cotton dust standard of 1.0 mg/M^3 as measured by an area sampler or 0.5 mg/M^3 VE, at the choice of the customer. Up to November 18, 1976, opening or picking rooms in 156 mills had been equipped or committed to engineering controls.

As of November 24, 1976, 25,510 cards have been equipped with some kind of Pneumafil Corporation lint and dust control systems. The first installations on cards were early in 1961 following experimental work which began in 1959. In March, 1972, we began to write performance warranties on lint and dust control systems for cards. We have equipped almost 7,000 cards under performance warranty to achieve 1.0 mg/M^3 dust levels as measured by an area sampler or 0.5 mg/M^3 VE.

DRAWING, COMBING AND ROVING AREAS

Engineering controls and required air quantity for capture of the dust generated by drawing frames are described and illustrated in the Pneumafil NIOSH Research Report already mentioned. This dust capture technology is still relevant and in theory, if combined

with properly applied preseparators and filters, should achieve 0.2 mg/M³ VE $\overline{X}$. However, there is very little actual experience and data to show that this is true. Our confidence is based solely on our long time familiarity with these machines. Pneumafil Engineers developed the first pneumatic roll clearer system for draw frames in the early 1950's. Now all draw frames, wherever built, are equipped with a similar system. We have made measurements of the dust concentration of air exhausted by the collector unit which is a part of the pneumatic systems. We find that surprising quantities of dust are cleaned out of the cotton sliver and discharged into the room. If the frames are equipped with power creels requiring dust control hoods, the required air quantities are large and the system much more expensive. Electrostatic precipitators will not be required to achieve a 0.2 mg/M³ VE $\overline{X}$ dust level but in most cases the necessary filters, for lack of space inside the card room, must be erected on the roof or some other place outside of the production area.

The Pneumafil/NIOSH Research Report describes the dust capture systems required to capture the dust generated on combers to achieve a 0.2 mg/M³ VE $\overline{X}$ dust level. The technology described there is equal to the job and, when combined with properly specified preseparators and rotary drum filters, the dust level in comber areas can be controlled to that level. The combers in 15 mills in the U.S. are equipped with Pneumafil systems of this type. Some of them, however, are not equipped with automatic filters. This experience makes us confident that the required performance can generally be achieved. But it must be pointed out, that actual tests against any dust level have not been made. None of these systems have been sold under a performance warranty.

There is practically no experience and we have done no serious research to correlate the performance of exist-

ing engineering controls for cotton dust in the roving areas with any specific cotton dust standard. However, Pneumafil Engineers have developed pneumatic clearer and photoelectric stop-motion systems and have been working with roving frames since the early 1950's. The pneumatic roll-clearer system for roving frames is similar to drawing. The fiber waste is separated from the air-stream in a collector unit at one end of the machine by a screen but most of the dust is blown back into the room. Measurements of the dust concentration discharged by collector units on roving frames is about half what we find from drawing frames, but the quantities are still a significant contributor to the dust levels in card rooms.

A 0.5 mg/M^3 VE $\overline{X}$ dust level in a roving area should be achieved by capturing the discharge from the collector unit on each roving frame and conventional filters as described in the Pneumafil/NIOSH Report. A preseparator would not be required since this function is accomplished by the screen in the collector unit.

In the roving areas in many mills producing medium to fine counts this type of engineering control should suffice for achievement of a 0.2 mg/M^3 VE $\overline{X}$ dust level. However, in coarse count mills using relatively low grade stock and manufacturing products, such as industrial fabrics, it will generally be necessary to draw high air quantities (5,000 cfm) through the flyer area. This can be accomplished by mounting a rectangular plenum inside or behind the Samson with suction slots on the flyer side. Mounting a shield on the aisle side of the flyers along the length of the frame (similar to the guard which Saco-Lowell furnishes for the popular Rovematic) would complete the capture system. Automatic filters as already described would take out the dust with necessary efficiency. Electrostatic filters are not required. As with draw frames and combers, our experience indicates that all available space for filters in the card room

will have been used and these filters for the roving area must be located in insulated houses on the roof or in some other area outside the building.

After the roving area, we run out of factual and comprehensive experience. From this point, everything is educated guessing because we have no basis of technical studies and we have no practical experience in meeting a specified dust standard.

SPINNING

The yarn manufacturing process following roving is spinning. The spinning frame is a maximum challenge for the cotton dust control engineer. Typical modern ring spininng frames will be 30½″ wide and up to about 55′ long. The head-end gearing cabinet is enclosed. At the foot-end of the machine is a cabinet containing a collector unit similar to the ones described for drawing and roving machines. Between these end cabinets from floor to top of creel and from side to side the spinning frame is wide open. This openness is essential to the spinning frame's operating efficiency because it enables the overhead travelling blowers to reduce accumulations of lint and fly on the operating parts of the machine. This travelling blower is even more important to yarn quality by controlling accumulations of waste on the roller beam and around the drafting system and especially at the ring rail. One blower cleans many frames so the trackage must continue over the aisles at the ends of the frames.

In the last decade, automatic doffing machines have been developed. Some are mounted permanently to the machine and others run up and down the length of the spinning frame guided by floor tracks or rails along the side of the frame. Automatic piecing-up devices are also beginning to come into use. These recent developments tend to decrease the numbers of people exposed to the dust in spinning rooms.

Practically all spinning frames are equipped with a broken ends collection system. This equipment has several purposes, the first of which is to capture by vacuum (3 or 4 cfm/spindle) any yarn that may break between the nip of the rolls and the bobbin. When this occurs, the drafting system continues to feed yarn through the rolls which would otherwise break down more ends and cause yarn defects unless controlled. Another purpose is to capture whatever fly and dust is generated at the drafting system. All of this lint, fly and dust is carried through the orifices into the flute and through the flute elbows into the header. This is a duct which runs the full length of the frame into a collector unit at the foot end.

To decrease the dust level in a spinning room, the first and obvious thing to do is to capture the air and dust discharged at the collector unit, duct it to efficient filters, then to the air conditioning apparatus room for temperature and humidity correction before it is returned to the spinning area. Because of the overhead cleaners this is only possible when there is access to a suitable area under the floor of the spinning room in which the necessary ductwork can be located. Based on our experience, there will not be any space in the production areas to locate these filters. They must be located on the roof as described for some of the previous processes or in the air conditioning apparatus room upstream of the washers. Such space will be rarely, if ever, available unless the system is coordinated with new construction for additional air conditioning equipment.

Collecting the collector unit discharge does not achieve the required level, the only alternative is to move more air through and away from the yarn producing areas of the spinning frame through openings in the floor and out through ductwork under the floor to filters and air conditioning apparatus and back to the room through

the supply-air system. The dust generated in the space between the thread guide and the ring rail on each side of the frame must be controlled. We can anticipate a spindle speed of about 12,000 rpm. At this speed, dust particles will be thrown off the ballon at a velocity of 6,000 fpm (2″ ring). For complete control, we must limit these high velocity particles to the confines of the spinning frame. To do this, a barrier must be erected at each side of the frame from floor to top of bobbin. Then, all of the air which is being drawn out of the room through the openings along the floor under each frame would enter this semi enclosure between the top of the barrier and the bottom edges of the broken ends collection system header.

Unfortunately, this is not possible because the barrier would interfere with the piecing-up of broken ends whether manual or automatic. It would prevent proper cleaning of the ring and traveller area by the overhead travelling blowers. It would tremendously increase the accumulation of lint and fly on the operating mechanism below the roller beams requiring extensive and expensive manual cleaning. It would interfere with the application of automatic doffing mechanisms. Such a combination would reduce the operating efficiency to such a low level that the machine would be useless.

Without the barrier, the only alternative is to move massive quantities of air through the floor openings. We do not have any data to indicate what these air quantities should be to achieve dust levels such as .2 mg/M^3 VE $\bar{X}$ in coarse yarn mills but our experience indicates that they would be impractical in existing mill construction. In the new mills built in the 1960's with underfloor returns we have found that maximum air conditioning supply air quantity uses about 6 cfm per spindle. There will be air current, humidity and temperature problems if this figure is exceeded. We believe

that at last 11 cfm per spindle would be necessary in many mills.

Some thinking has been given to another alternative which would totally enclose lines of spinning frames so that the machinery would operate in one environment and the operator in another. Such an arrangement would still require the wearing of respirators when it was necessary for the operator to enter the machine area. Physically, such an arrangement would require complete reorientation and modification of existing manufacturing facilities and machinery layouts.

We, therefore, conclude that the only practical approach in existing spinning rooms is the capture and filtering of the air discharged by the broken ends collection system in those mills affected by the standard where underfloor space permits the installation of air handling ductwork sized to handle 1000 to 2000 cfm per frame. Our data indicates that this procedure would bring all but a few maximum-problem mills into compliance with a 0.5 mg/M^3 VE $\overline{X}$ dust standard. We suggest that this is all that the industry can do and that any standard below that is completely impractical.

TWISTING, WINDING, SPOOLING, WARPING (YARN PREPARATION)

The configuration of twisters is very similar to spinning but twisters have no drafting system and no broken ends collection system. Overhead travelling blowers are used on twisters, as on spinning frames, so any air duct must go out through the floor. Twisters do not generate as much dust as spinning and our data indicates that twisting room dust levels should not exceed .05 mg/M^3 VE $\overline{X}$. However, the data also indicates that 67% of the twisting room dust levels would exceed 0.2 mg/M^3 VE $\overline{X}$. The only available approach is to move massive air quantities through openings in the floor un-

der and along the length of the machine. As shown in our discussion of spinning, this is not a practical approach in existing cotton mills.

Winders (Schlafhorst, Leesona, Abbott, Schweiter) can be approached by air ducts from overhead and some popular models have built-in dust capture systems involving air quantities up to 21,000 cfm per machine (Schlafhorst). On others suction duct might be located in the machine effectively but air quantities will be high. We have estimated 10,000 cfm average where dust control equipment is required to achieve 0.5 mg/M^3 VE $\overline{X}$.

All spoolers (18 to 378 spindles, most machines 198-Barber-Colman) are equipped with a built-in lint and dust capture system. When combined with proper filters the area around these machines should not exceed 0.5 mg/M^3 VE $\overline{X}$. Modification of the suction plenums inside the machine and the filters to handle 50 cfm per spindle instead of the original 30 will improve this performance.

Pneumafil Corporation has been making lint and dust control systems for application to warper creels and comb areas for many years. However, this equipment has never been evaluated for performance against any specified dust level. Available dust level measurements indicate that warper areas will be less than 0.5 mg/M^3 VE $\overline{X}$ without engineering controls.

SLASHING AND WEAVING

We have no experience on slashers but it appears that most cotton dust is generated at the feed end of the machine. Local exhaust ventilation should control the dust in this area. Filters used on previous processes would not be satisfactory on slasher or weaving applications because the high humidity and sizing would blind the pores of such filters. Slashing and weaving area filters (AAF, AirMat or Rollamatic, Luwa, RDF) would

require some type of roll-up media which is automatically replaced after it loads to capacity with collected dust. Filters of this type have been used in the industry for many years. They are much more expensive to operate because of the filter media usage.

The loom is a compact machine without any built-in dust control system. It presents the same kind of challenge to the dust control engineer that we have discussed for spinning frames. It is a wide open machine, as it must be, for effectiveness of travelling overhead and manual cleaning. The operator must work over the shed at the front and over the beam at the back for access to the harness when replacing broken ends. Thus, any dust collecting hoods above these areas, as some have suggested, must be located at such height in order not to interfere with performance of work by the weaver, that they would not be effective.

Effective control would require directing the air, supplied to the weave room by air-conditioning ducts overhead, downward through the mechanisms of the loom and out through the floor. This would require openings in the floor, covered for safety with some kind of grid, so that air and dust could be carried away by ductwork under the weave room floor. These openings should be placed directly under the shed and harness area. We do not know what air quantity would be required to achieve any given dust level in the room but we estimate that at least 1000 cfm per loom would be required in coarse count mills to hold the dust level to 1.0 mg/M^3 VE $\bar{X}$.

We have combined all of the dust level readings for weaving rooms that we can put together from all sources. Nine hundred seventy-one measurements from 63 mills show that 11.5% of the weave rooms would require the control system outlined to reduce existing dust levels to

1.0 mg/M³ VE $\bar{X}$. Unfortunately, after discussion with some of our respected competitors and others, we estimate that not more than 10% of the weave rooms in the industry have the required underfloor access. There is no assurance, however, that the 10% with underfloor access are the ones that need it. Certainly, any more extensive application of this arrangement, not to mention increased air quantities, would require massive and unreasonable reorientation of textile mill structures and machinery arrangements, including moving machinery out of the mill, digging up floors (sometimes concrete), digging air tunnels and constructing additional buildings or expanding existing buildings to house massive filters and air conditioning equipment.

We assume that everyone has received a copy of our cost estimates (Hocutt Attachment #1) and that it is not necessary to read all the figures.

CONCLUSION

In conclusion, we must point out:

1. From an engineering control standpoint, it is technologically feasible to control cotton dust levels to .5 mg/M³ VE $\bar{X}$ and .2 mg/M³ VE $\bar{X}$ levels in the opening, picking and carding areas of virtually all cotton textile mills and the equipment to do so is commercially available for introduction into presently existing facilities without unreasonable reorientation and modification of those facilities and machinery and without significant interference with the production process.

2. From an engineering control standpoint, it is technologically feasible to control cotton dust levels to .5 mg/M³ VE $\bar{X}$ and .2 mg/M³ VE $\bar{X}$ levels in most drawing, combing and roving areas and the equipment to do so is commercially available. However, in a number of instances, such as coarse count

mills using low grade stock and in mills where the drawing frames are equipped with power creels requiring dust control hoods, additional insulated houses or rooms will have to be constructed on the roof or in some other area outside of the building.

3. In the area of spinning, it is technologically feasible from an engineering control standpoint to reach a dust level of 0.5 mg/M³ VE $\overline{X}$. Because of the various types of equipment required to maintain the efficient operation of the spinning frame, and because of the extensive modifications that would be required, including a virtual reinvention of the "wheel," to conceive of anything less than a 0.5 mg/M³ VE $\overline{X}$ requirement is totally impractical. The only practical method of controlling dust levels in spinning is to capture and filter the dust through the broken end collection system, but only where underfloor duct work can be installed to handle 1000 to 2000 cfm per frame and this cannot be done in many instances.

4. It is technologically feasible from an engineering control position to maintain a 0.5 mg/M³ VE $\overline{X}$ dust level in twisting. As in spinning, the dust control method used in twisting is to move massive amounts of air through openings in the floor under the machine. This too, is not feasible in many instances.

For winders, we estimate it would take an average of 10,000 cfm on required dust control equipment to achieve a 0.5 mg/M³ VE $\overline{X}$ dust level. We cannot offer any estimates on feasible controls beyond this point.

Spoolers are now equipped with built-in lint and dust capture systems and can reach a 0.5 mg/M³ VE $\overline{X}$ dust level.

It is our opinion, that with the equipment now in place in warping areas, a 0.5 mg/M³ VE $\overline{X}$ dust level can be maintained.

5. From an engineering control standpoint existing local exhaust around slashers can maintain a dust level of 1.0 mg/M³ VE $\overline{X}$.

The loom offers many of the same problems as outlined in spinning in the control of dust levels. Here again, massive amounts of air must be directed downward *through* the loom; to be extracted through underfloor ductwork. At least 1000 cfm per loom would be required in coarse count mills to achieve a 1.0 mg/M³ VE $\overline{X}$ level. To do more than this would require massive and impractical reorientation in a textile mill.

6. Obviously, based on this factual data it is economically and technically unfeasibe to achieve a raw cotton dust level of 0.2 mg/M³ VE $\overline{X}$ in processes past roving. Also, the capacity of the dust control industry is reflected by the total sales of $12 million which represents the largest sales year ever. At best, this capacity could increase approximately two to three times with the new demand. This means that if sales were to reach $30 million, it would take at least eleven years to supply the equipment necessary to reach a level of 0.2 mg/M³ VE $\overline{X}$ in opening-carding only.

Cost/Dollars
Cotton Dust Control Systems

Textile Process	0.5 Mg/M^3 VE $\bar{X}$ Equip. Cost	Maintenance Cost/Year	Energy Cost/Year	0.2 Mg/M^3 VE $\bar{X}$ Equip. Cost	Maintenance Cost/Year	Energy Cost/Year
Opening	6,256,383	133,312	589,963	25,818,973	262,852	1,190,900
Picking	21,914,519	397,241	2,254,650	42,762,527	542,545	3,345,151
Carding	29,337,703	672,046	3,751,459	121,868,495	1,527,603	10,542,040
Sub-Total	57,508,610	1,202,599	6,596,072	190,449,995	2,333,000	15,578,091
Drawing	13,697,778	132,622	1,368,075	44,212,483	411,112	5,000,936
Combing	—	—	—	6,874,565	67,848	813,529
Roving	5,412,737	52,754	528,683	37,169,720	429,793	4,088,148
Opening-Roving Sub-Total	76,619,125	1,389,781	8,492,830	278,706,763	3,241,753	25,480,704
				0.5 Mg/M^3 VE $\bar{X}$		
Spinning	13,517,498	379,803	1,582,088	13,517,498	379,803	1,582,088
Twisting	—	—	—	—	—	—
Winding	14,383,500	95,900	1,389,080	14,383,500	95,900	1,389,080
Spooling	2,965,900	21,188	327,485	2,965,900	21,188	327,485
Warping	—	—	—	—	—	—
Spinning-Warping Sub-Total	30,866,898	496,891	3,298,653	30,866,898	496,891	3,298,653
	1.0 Mg/M^3 VE $\bar{X}$			1.0 Mg/M^3 VE $\bar{X}$		
Slashing	—	—	—	—	—	—
Weaving	41,560,769	204,944	6,151,937	41,560,769	204,944	6,151,937
Total	149,046,792	2,091,616	17,943,420	351,134,430	3,943,588	34,931,[illegible]

These figures represent the estimated economic impact on the industry as of 2/11/77. The totals do not include the following credits allowed for dust control systems purchased by the industry before 2/11/77:

Towards compliance with 0.5 mg/m^3 VE $\bar{X}$ standard-opening = $12,151,541, picking = $5,685,038, carding = $32,333,474, drawing = $210,441, Total = $50,380,494.

Towards compliance with 0.2 mg/m^3 VE $\bar{X}$ standard-opening = $10,693,356, picking = $5,002,834, carding = $28,453,457, drawing = $185,188, Total = $44,334,835.

EXHIBIT 69

Statement of L. K. Fitzgerald

* * * * *

The pertinent portions of the RTI summary table, then, are:

Table I-6. Total Installed and Annualized Compliance Costs: All Sectors
(Costs in Millions of Dollars)

Industry Sector	Exposure Limit (mg/M3)	Installed Cost	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
Cotton Ginning	0.2	292.2	47.0	13.2	30.3	90.4
Yarn Production	0.2	984.4	158.3	15.6	67.9	241.6
Cotton Weaving	0.2	1387.9	223.1	40.7	86.3	350.1
Total	0.2	2664.5	428.4	69.5	184.5	682.1

It is suggested that an addition needs to be made to the capital requirement in the foregoing table, since the data is based on the assumption that the industry is already in compliance with a 1.0 dust level. This is not the case, according to the IIS. On page V-8, the IIS indicates that a capital expenditure of $143.3 million is necessary to bring the industry into compliance with a 1.0 level. This sum will have to be expended by the industry, in addition to that listed in Table T-6.

* * * * *

The $143.3 million represents additional equipment costs, and obviously this equipment will require Direct Operating Cost and Energy Cost, just as does the capital equipment considered in Table I-6. Therefore Annualized Compliance Costs will be recalculated. Annualized Capital Charge, Direct Operating Costs and

Energy Costs are assumed to increase proportionately to the increase in Installed Costs of compliance equipment.

With this addition, Table I-6 would then become a new table, Table I-6-a, as follows:

Table I-6-a. Total Installed and Annualized Compliance Costs: All Sectors
(Costs in Millions of Dollars)

Industry Sector	Exposure Limit (mg/M3)	Installed Cost	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
Cotton Ginning	0.2	292.2	47.0	13.2	30.3	90.5
Yarn Production	0.2	1127.7	181.3	17.8	77.7	276.8
Cotton Weaving	0.2	1387.9	223.1	40.7	86.3	350.1
Total	0.2	2807.8	451.4	71.7	194.3	717.4

From this table, total annualized costs of the Yarn and Weaving Sectors are seen to be $717.4 million instead of $682.1 million from Table I-6.

The Inflationary Impact Statement points out, and reiterates, that the capital requirement for the equipment necessary for a 0.2 dust compliance presents a problem of some magnitude. The IIS also makes the point, correctly, that the annualized capital charge is by far the largest component of total annual cost.

* * * * *

Since, admittedly, there would be considerable difficulty in capital formation at the level required by the 0.2 dust standard, it is not unreasonable that the industry would use the shortest available asset life to increase cash flow. Thus, the ATMI suggests that a 9 year life be used in the foregoing formula, instead of 14 years. When this is done (by the ATMI economist),

the annualized capital charge rate becomes .19864 instead of .16075.

Let us then go back to Table I-6-a and further revise the Annualized Capital Charge, by sectors, as follows in the new Table I-6-b.

Table I-6-b. Total Installed and Annualized Compliance Costs: All Sectors
(Costs in Millions of Dollars)

Industry Sector	Exposure Limit (mg/M3)	Installed Cost	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
Cotton Ginning	0.2	292.2	58.0	13.2	30.3	101.5
Yarn Production	0.2	1127.7	224.0	17.8	77.7	319.5
Cotton Weaving	0.2	1387.9	275.7	40.7	86.3	402.7
Total	0.2	2807.8	557.7	71.7	194.3	823.7

Examination of Table I-6-b now shows the Total Annualized Cost, still using basic data from the Inflationary Impact Statement, to be borne by the Yarn and Weaving sectors, to be $823.7 million instead of $682.1 million.

At this juncture, we feel it would be helpful to OSHA, in considering the impact of this cost increase, for us to examine it broadly in terms of other data for the Yarn and Weaving Sectors.

The IIS indicates that during 1972 (the only year for which this data is given) the six SIC codes which made up the Yarn and Weaving Sectors, processed 3,836.9 million pounds of cotton. (Table VI-2). Without going through the exercise of allocating compliance cost between various sectors, and of subsequently relating it to individual sector throughput let us simply

look at total dollars of compliance cost versus total pounds processed. The 3,836.9 million pounds of cotton processed by these sectors will have to bear an annual compliance cost of $823.7 million. This works out to be an average of 21.3 cents per pound, added cost.

There is no industry figure which will correctly identify the average yarn count being manufactured. It has been estimated variously between 18/1 and 24/1. I don't know what it is, but I estimate it to be somewhere around 20/1. Precise identification is not really important to the purpose at hand.

I have access to the variable labor costs for producing twelve different years, in typical mills, ranging from 18.5/1 to 24.0/1. The actual labor costs, from stock opening through the winding of spun yarn, average 15.95 cents/pound.

Likewise, I have access to variable labor costs for weaving yarns of the same count range into fabric in typical plants. Thirty-three different fabrics have an actual average weaving cost of 13.80 cents/pound. The term "weaving cost" embraces all processes incurred from wound spun yarn through the inspection of woven cloth.

Adding these two labor costs, there is a total of 29.75 cents/pound for woven fabric. I do not represent this as being an absolutely correct variable labor cost, for all fabrics, for all plants, but it is the best approximation I can put together, and is sufficiently good for the purpose at hand.

If we compare the average added compliance cost of 21.3 cents/pound, with an average labor cost of 29.75 cents/pound, the compliance cost is seen to be in the order of two-thirds—I repeat, two-thirds—of the labor costs for producing fabric. I do not doubt that differing labor costs could be established, and that they could show compliance costs to be anywhere from 50 to 75% of ex-

isting labor costs. The impact of the increase is of such magnitude that any figure in the 50 to 75% range is awesome to consider.

It will now be instructive to examine the $823.7 million revised annual cost increase in light of the earnings of the sectors involved.

In Table VI-5, the IIS indicates that the annual value of shipments of six SIC sub codes was $12,606.8 million in 1972. In Table VI-7a, and in the discussion immediately preceding it, the document concludes that profit on sales, for the entire textile industry, was 2.5% in 1974. However, since the value of shipments and the cotton consumption data used in the IIS, are from the year 1972, subsequent calculations should and will be made within that one year. Actually, return on sales for the entire industry was 2.56% in 1972, which is not materially different from the 2.5% quoted by the IIS in 1974.

The "value of shipments" for the entire textile industry was $28,071.5 million for 1972, and "sales" reported for that same year were $25,616 million. It is assumed that the 2.56% return on sales is equally applicable to the value of shipments.

While the after tax profit on the value of shipments of the six SIC sub codes is not known, some means of estimating it is needed for a comparison to be made between after tax profit and compliance costs.

If the return on shipped value for all of the twenty-nine SIC textile sub codes is 2.56%, the return for the six sub codes in question could reasonably be assumed to be between 2.0 and 3.0%. On that basis, earnings on the $12,606.8 million of shipped value were in the range of $250-375 million. Using either earnings figure, the added annual 0.2 cotton dust compliance cost of $823.7 million would throw these six sectors into an annual loss in the order of half a billion dollars.

The IIS suggests that price increases will provide the solution. For example, Table I-9 calculates that cotton weaving mills would find it necessary to increase selling prices 17.8% to retain their pre-compliance return on investment. The 17.8% increase is understated, since the actual 0.2 compliance costs, calculated by the ATMI from the IIS base data, are somewhat greater than those used in arriving at the 17.8% figure. Perhaps, another percent or so should be added on—I have made no effort to calculate it, since it is highly debatable whether the consumer will pay for either an 18% or 19% increase.

Without involving ourselves in conjecture as to whether the consumer can or would pay an increase of this size, one effect of it is quite clear. Cotton's share of the market has been steadily declining, from around 70% in 1950 to around 30% in 1974, as seen in Table C-20. During the same period, according to Table C-23, the ratio of the price of manmade fiber to cotton has declined from around 1.25 to around 0.80. The message of these trends is evident.

You may be absolutely certain that cotton textile plants, faced with cotton dust abatement costs of the size indicated, will accelerate the move from cotton as fast as the consumer can be persuaded to further adopt manmade fibers. An 18/19% increase in the price of cotton fabrics versus no increase in comparable fabrics of manmade fiber, will supply much of the persuasion. This impact does not fall on the mills, but falls on the grower

From a third viewpoint, the capital requirement for compliance equipment should be viewed in the light of historic industry expenditure for new plants and equipment. In so doing, 1972 capital expenditures should be considered, again in the interest of using data from the same year throughput.

From the "Census of Manufacturers", Bureau of Census, the six SIC sub codes together invested $595.4 mil-

lion in new plants and equipment in 1972. Please compare this figure with the compliance capital of $2,515.6 million. This says that, based upon 1972, more than four years of the investment of these sectors will have to go into compliance equipment. Or to say the same thing in a different fashion, plants would make no investment in improved productivity, or in buying equipment to meet changing consumer demands for new products, for four years. The longer term implication of this is serious. In a worldwide, highly competitive, textile market, the longer term application of this is obvious.

* * * * *

OSHA was engaged in finalizing regulations for the abatement of both noise and cotton dust in the textile industry. Since each of these will have a profound effect on the economics of the industry, OSHA could hardly disregard the effect of either, in considering the other. The industry expected that and believed that OSHA recognized this fact and had been informed that Bolt, Beranek and Newman (BBN), the OSHA contractor for the noise study, had been retained by OSHA to put together a total economic impact analysis, combining their own noise abatement analysis with the RTI analysis of cotton dust abatement. The industry has been anxiously waiting for this final combined study of BBN, but has not yet seen it. We have now learned that OSHA has, after the work had started, *cancelled* the contract for the reason, according to David Bell of OSHA, as quoted in the Noise Regulation Reporter (BNA, March 14, 1977, p. A-15), that it was "not in the taxpayer's best interest." This is indeed curious as there are large numbers of taxpayers who are also consumers or whom the burden of the inflationary impact of both standards will, in large measure, ultimately fall. It is also curious in view of Bell's own indication that, based on BBN's analysis, the costs were "staggering." Since such an analysis is obviously of utmost importance, a brief one will be presented here.

The whole of the textile industry is not affected by a noise abatement program. Almost without exception, the impact is felt by the greige sector of the industry, which is made up of the selfsame six SIC sub codes that are affected by cotton dust abatement. It is essential to add the costs associated with noise regulation to those costs already examined in connection with dust abatement, if we are to understand what is being proposed.

BBN estimated that the capital cost to the textile industry for compliance with a 90 dBA standard was $1,157 million, and $2,467.6 million for an 85 dBA standard. The textile industry was in complete disagrement with BBN's estimate, and documented, in great detail, its reasons.

* * * * *

We can offer no factual cost data for compliance with an 85 dBA regulation, nor can anyone else, since major equipment replacement, not retrofit, is involved. The required replacement equipment does not exist—has not been designed. Suffice it to say that loom replacement alone could conservatively be placed at $13 billion for an 85 dBA level.

On the other hand, the attainment of a 90 dBA, as far as looms, spinning and twisting are concerned, would cost $2,478 million. This is the figure which the industry calculated, and presented to OSHA, with full and complete back up data. When this compliance figure was presented at the noise hearing, it was not challenged on cross-examination. The textile industry will adhere to the $2,478 million figure.

If we return to Table I-6-b, and pick up its totals, and add to them the capital costs incurred from compliance with a 90 dBA noise standard, calculating annualized capital charges in the same fashion, we arrive at the following tabulation, Table I-6-c.

Table I-6-c. Total Installed and Annualized Compliance Costs: All Sectors
(Costs in Millions of Dollars)

Industry Sector	Exposure Limit	Installed Cost	Annualized Capital Charge	Direct Operating Cost	Energy Cost	Total Annualized Cost
Cotton Dust Abatement	0.2 mg/M³	2807.8	557.7	71.7	194.3	823.7
Noise Abatement	90 dBA	2478.0	492.2	-0-	-0-	492.2
Total		5285.8	1049.9	71.7	194.3	1315.9

The total annualized cost of compliance is seen to be $1,315.9 million. This is the figure for which OSHA is solely responsible. This is the figure that the six SIC sub codes would have to meet, and which has to be explored in the light of previously developed data for this sector.

The six SIC sub code sections processed 3,836.9 million pounds of cotton in 1972. An added annual compliance cost of $1,315.9 million works out, therefore, to be an average increase in cost of 34.3 cents/pound. This compliance cost, per pound, is greater than the earlier quoted average variable labor cost of 29.75 cents to produce a pound of woven fabric. Can a labor intensive industry more than double its labor cost and survive?

It was developed that the after tax earnings of that portion of the industry in question were in the range of $250-375 million. An annual cost increase of $1,315.9 would put this segment in the red, by something like a billion dollars annually.

The IIS calculates that price increases of 17.8% would be required in the weaving sector for it to maintain its pre-compliance return on investment. Annual compliance costs for both noise and cotton dust are $1,315.9 million, 1.93 times as great as the $682.1 million figure used in

the IIS calculations. Admittedly, it is not correct to assume that price increases, to retain a given return on investment, vary directly with cost increases, as the IIS points out on page VI-37. Even so, and conservatively, if the 17.8% increase be ratioed upward by 1.93, it becomes an increase of 34.4%. It would be unwise to use this as a firm figure, but it appears reasonable to infer that prices for woven fabric would need to be increased within a 30/40% range. If you feel a need for a precise figure, I feel sure that the RTI would be glad to calculate one.

The six SIC sub codes invested $595.4 million in new plants and equipment in 1972, the year under consideration. A capital requirement of $4,993.3 million (excluding capital for gins) for noise/dust compliance means that for 8.4 years, there would be no investment in new plants and equipment.

The amount of capital available for investment, investment in whatever, is the sum of after tax earnings and depreciation. It would be helpful to OSHA's deliberations if we could make this data available for the six SIC sub codes, but it simply doesn't exist.

As one possible means of ballparking a figure, data from Table C-17 may be used. For 1972, this table shows, for the textile industry, that $0.05 per sales dollar is available for investment, with the IRS indicated as the source. This figure represents the entire industry, and not just the six SIC sub codes. I do not know if, for the six sectors, the figure should more correctly be higher or lower. But if we assume that the $0.05 per sales dollar be equally applicable for all industry sectors, then six SIC sub codes have available for investment $630.4 million, from a shipped value of $12,606.8 million.

From this standpoint, 7.9 years of all of the capital available for investment will have to go into abatement

equipment at the expense of any productive equipment purchases.

It is most interesting how closely the two time periods agree, 8.3 years and 7.9 years, when the one is derived from historic capital expenditure and the other from a calculation of capital available for investment. It would be prudent to use an 8 year period as that which we are facing.

OSHA understands this implication for the long term as well as anyone. It is inconceivable that OSHA would push an industry, which earns 2.5% on sales, half that of the all industry average, down this road. There is some amount of capital that is useable for noise and dust abatement. I don't know how much it is, but it most certainly is not all the capital available, for all purposes, for the next 8 years. OSHA is faced with the problem of deciding how much of either of the abatement programs it wishes to mandate. The simple fact of life is that OSHA can't have all of both.

* * * * *

The time period granted for compliance is most important. The IIS makes the point quite clearly, when it states, on page VI-48, "The evidence in Table VI-11 clearly indicates that unless the compliance capital investments are spread over a substantial number of years, all the companies engaged heavily in cotton yarn production will face severe difficulty in financing compliance capital for the 0.2 mg/M^3 and the 0.1 mg/M^3 exposure limits, and the difficulty will be more intense for the smaller companies."

We don't know what OSHA's final decision with regard to dust level standards will be, and consequently don't know how much dust control equipment will be required. However, OSHA needs to remember that dust control

equipment suppliers have a limit to the quantity of equipment they can supply annually. I am told that the largest year of sales the cotton dust control industry ever had in this country was $12 million. I would expect these people to increase their delivery capability by perhaps two, or three times at the very outside. I doubt that new suppliers will come into the picture to any consequential degree, since once the needed equipment was supplied, the demand level would be too low to support added suppliers. If we assume that delivery capacity will go up to $30 million, and that optimistic assumption will require a lot of doing, delivery will require five years for the dust levels proposed by the ATMI, and more than eleven years if OSHA should require a 0.2 level in opening/carding.

* * * * *

The installation of automatic feeding equipment in cotton opening rooms, versus manual feeding, has begun in the industry, and over a period of time, more and more plants will make these installations, whenever they become economically and technically desirable. It is doubtful that OSHA is prepared to mandate the automation of all cotton opening rooms to eliminate the manual handling of cotton. These systems are expensive. If OSHA is actually seriously considering mandating this route, we are in a whole new, and as yet undetermined ball game of cost.

Picker tenders normally remove "picker laps" from picking machines and place them on trucks or conveyors, in the performance of their assignments. Is OSHA prepared to mandate the elimination of the picking process?

Card tenders manually remove picker laps from trucks or conveyors and place them into the feeding position at the card. What does OSHA propose here? Is OSHA saying that the chute feeding of cards, which will eliminate manual lap handling by both picker and card tenders, will be mandated? We are really in a new ball game of costs, if that be OSHA's intention.

With no effort to produce a refined cost figure for automated opening, cleaning and chute feeding, let me give you an approximate capital cost.

Assuming the correctness of Table B-13 in the IIS, there are 15,796 high speed cards producing 100% cotton and 9,030 high speed cards on cotton blends. If half the cards on blends be occupied by cotton, then there are 20,311 high speed cards producing cotton. Using the same procedure, from the same table, there are 16,224 cards of conventional speed being operated on cotton.

The first step in the installation of chute feeding is the conversion of conventional speed cards to high speed, or their replacement with new high speed cards. Conversion costs are in the order of $12,000 per card and new cards, depending upon the supplier, are around $30,000. An average of the two, since both courses would be followed by the industry, approximates $21,000.

With an optimistic ratio of 4:1 productivity, high versus conventional speed, 4,056 card conversion/replacements would have to be made to the existing 16,224 conventional speed cards. This comes to be $85.2 million.

The existing 20,311 high speed cotton cards, plus the 4,056 conversion to be made, total at 24,367 cards. The IIS estimates, on page B-71, that 5,000 high speed cards are chute fed. A portion of these are actually processing manmade fiber, but in the interest of conservatism, assume that all 5,000 chute feeds are applicable to highspeed cotton cards. This leaves 19,367 to be chute feed equipped.

In considering automated opening, the ATMI estimates that 5% of the high speed cards producing cotton are supplied from automated opening room bale feeding systems.

But in the interest of conservatism, let's double the figure, and assume that 10% of the new high speed cards are so supplied. This works out at 1,580 cards, which when deducted from the 24,367 cards under consideration, leaves 22,787 to be supplied from automated opening rooms.

One of the major suppliers, the one referred to by RTI, has supplied me with recent and typical quotes for chute feeding and for automated bale feeding and opening. On a per high speed card basis, the costs quoted are $10,500 for chute feeding and $23,250 for opening room automation.

The installation of chute feeding on 19,367 cards comes to be $203.4 million. The installation of automated opening to supply 22,787 cards comes to be $529.8 million.

The summation of card conversion/replacement, chute feeding and automated opening is a total cost of $818.4 million. This figure is not represented as being perfectly correct, but it unquestionably is the right order of magnitude. This is the background of having said that if OSHA is considering mandating the elimination of manual stock handling, it is a whole new ball game.

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EXHIBIT 78

Submission of Amalgamated Clothing and Textile Workers Union

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D. *Technological and Economic Feasibility*

The Secretary has based the proposed permissible level of dust and the seven-year delay in its effectuation on the *Technological Feasibility Assessment and Final Inflationary Impact Statement* prepared by the Research Triangle Institute. [18] This document starts out with the premise that "process modification, other than improved maintenance, has had little effect on dust concentrations" in yarn production. [19] Consequently, the RTI statement assumes that "the capture and removal of dust from the air at the point of generation (i.e., local exhaust ventilation) appears to be the most efficient method of dust control at the present time." [20]

The fact is that the RTI premise is wrong. Process modification has had a major effect on dust concentrations in yarn production. Indeed, those textile companies which have substantially reduced dust levels in their plants—and there are many which have done so—have relied primarily on the more modern machinery which has become available in recent years to accomplish their goal at a small fraction of what it would cost by means of the strategy assumed by the RTI, i.e., the use of retrofitted ventilation devices.

The high costs of compliance projected by RTI—and the delay associated with the incurring of such costs—flow from the assumption that the industry would choose the most costly strategy instead of the most efficient. A review of the record of what the textile industry has actually been doing will demonstrate the error in the RTI approach. Many companies have recognized the cost-effectiveness of combining dust reduction with mod-

ernization. Savings from the higher productivity yielded by more advanced technology are frequently greater than the increased capital costs and therefore result in actual reductions in unit costs.

1. *A Systems Approach to the Problem*

As noted by E. M. Afify, "the various measures and efforts taken by the textile industry to combat the dust problem . . . are far from being systematized." [21] In order to provide a unified approach to the task of dealing with the cotton dust problem, Afify has developed a set of guidelines based on "the systems approach being successfully applied in another pollution control field." He presents a flow diagram which throws light on the procedures and factors involved in assessing the feasibility of engineering controls for cotton dust.

The starting point in this analysis is the survey of dust concentrations "to identify the problem areas" and "to determine the state of knowledge of the dust emitted." [22]

Once the required information on the dust concentrations has been obtained, "the next step is to find out the possibility of altering the process to suppress the dust at the source . . . If neither the dust-concentration is smaller than the threshold limit set by OSHA nor the modification of the process turns out to be economically feasible, other channels of approach should be tried . . . The second channel of approach considers the possibility of modifying machine design to suppress the cotton dust at the source . . . The aforementioned approaches are basically elimination techniques . . . It is also worthy of note that *they must be applied to their limit first, whenever possible, before any control method be considered as they tackle the roots of the dust problem at the source before it spreads into the environment.*" [23] (Emphasis added)

It is not until the possibilities for process modification and changing machine design are exhausted that the "third avenue of approach" is suggested, which is "to find out if local ventilation can be installed as close as possible to the source to control the dust." [24] (The text of Dr. Afify's article is attached as Appendix 5.)

This sequence makes sense. Elimination of the dust before it enters the workers' environment is surely preferable to attempting to capture and remove it after it has been emitted into the environment. As noted by Hagopian and Bastress, "it is our observation that engineering controls in the form of ventilation systems and jerry-built enclosures can often be found about operations or processes which would not have required such 'add-on' devices if they had been properly designed in the first place. An underlying concept in many of the recommendations made in this report has therefore involved the provision of that technology necessary for the design of processes which do not require such controls by virtue of the fact that they do not result in excessive exposures . . . With today's costs of air cleaning equipment, ducting systems, and energy, elimination of the problem would probably be cheaper than attempting to control it . . . It is our belief that this sort of basic approach to developing 'engineering control' is the most correct one . . ." [25]

2. *Process Modifications and Machine Design Changes in the Industry*

The following technological advances have been implemented by many firms in the textile industry in recent years as part of the program to reduce cotton dust in the mill areas posing the most serious health hazards for textile workers:

(a) *Opening*

Automatic opening of bales of cotton and automatic feeding of cotton into the blending process have been substituted for manual opening and feeding.

(b) *Picking*

This process has been eliminated by feeding of stock directly from opening to carding in enclosed chutes.

(c) *Carding*

Stock is chute fed into the carding machine, which is either fully enclosed or has built-in air cleaning to minimize dust emission.

(d) *Spinning*

Open end or rotor spinning frames have replaced ring spinning frames. The new frames eliminate the need for roving and winding. The spinning is performed in enclosed rotors with built-in suction to minimize dust emission. This process has not been found suitable for all types of cotton yarns but it is presently producing yarns ranging up to 24s.

The RTI statement makes reference to these developments. It notes that "many of the modern machines are well enclosed and are equipped with dust capture devices as a standard feature." [26] However, in assessing the compliance costs for yarn production equipment, RTI fails to take into account the lower air flow requirements for the more modern machines. For example, the projected incremental costs for complying with target dust levels are the same for Open End Spinning Frames as for Ring Spinning Frames.[27]

The most serious deficiency in the RTI assessment is the assumption of a static state of technology. RTI simply assumes that the distribution of machinery in place as of the date of its survey (1973) would remain exactly the same in the future. No effort is made to

factor into the cost calculations the effects of existing or prospective technological improvements.

This failure is specially deplorable in view of the information readily available to RTI in the cited sources. One of these sources (*Technological Obsolescence in the Textile Industry*, prepared for the ATMI Tax Committee by its sub-committee on Technological Obsolescence, August 1974) furnishes the following information relevant to the RTI assumption of a static technology:

> "Rapidly increasing labor costs and scarcity, particularly in the last three years, have forced manufacturers into a fresh look at those technological developments which can contribute to a smaller workforce. It is difficult to quantify this effect, but it has been substantially larger in the last three years than in any earlier period, and in the half dozen years ahead, the pace of adoption of new technology for labor saving must accelerate." (p. 1)

"*Opening and Cleaning*

> "Development of systems to eliminate feeding of stock into hoppers by hand had met with little success until recently, however, there are now some 6/8 companies offering these systems." (p. 5) (The "automatic bale plucking systems" and "improved cleaning equipment" are attributed in the ATMI statement to "technological obsolescence" and the need to comply with government regulation. ATMI assesses the influence of the automatic opening as "major" and the improved cleaning equipment as "mid" or medium importance.) (p. 6)

"*Picking*

> "Other than maintaining existing pickers it is not anticipated that any significant capital expenditures will be made on pickers in the coming years as it is

anticipated that this manufacturing process will be eliminated by the chute feeding of stock directly from opening to cards." (p. 6) (The introduction of the Chute Feeding System is attributed to "technological and economic obsolescence." The ATMI characterizes the influence of this new system as "major.") (p. 7)

"*Cards*

"Of the 20,000 high speed cards which are in operation, 5,000 are chute fed, and this represents 17/18% of the productive capacity of the industry . . . most of (the investment in chute fed cards has) occurred within the last three years. This trend will have to continue, and those plants which run fairly constant fiber blends (as opposed to a highly-styled, fancy carding operation) will, without question, advance to chute feeding." (p. 8) (The reasons for the change to chute fed cards are given as "technological and economic obsolescence." The influence of this change is termed "major" by ATMI.) (p. 9)

"*Roving*

"The advent of the open-end spinning system has placed some question mark on the future of the roving frame, however, at this point, it is difficult to ascertain to what degree it will be affected . . . Because of the possibility of the roving process being eliminated by open-end spinning, we do not anticipate any substantial developments in this area." (p. 14)

"*Open-End Spinning*

"Basically, the open-end frame is supplied with sliver from a draw frame (obviating the need for a roving frame), passes sliver through a drafting systems into a centrifugal rotor and, thence, to a

wound package (obviating the need for a subsequent winding operation). For yarns in the coarser counts, unquestionably, there is cost improvement and reduced labor need. However, the yarns produced are different in characteristics than conventional ring-spinning yarns, usually requiring redesign of the end product. Open-end spinning is having an important impact on conventional ring spinning, but it will by no means obsolete ring spinning for many years to come, if ever. . . The open-spinning concept lends itself beautifully to the complete systems approach. This says that if a completely automated system (now available) be installed, from raw bale through finished sliver, and if open-end spinning be installed to operate from sliver, through winding, there then would be two basic processes which would replace eight conventional processes. It would appear inescapable that, for certain end products, the industry would go this route, but it is most difficult to predict the rate at which this will happen.

"As of today, there are in place and in operation 73,160 spindles of open-end spinning, and 95,592 spindles are presently on firm order for delivery during the remainder of 1974, and 1975/1976. Thus, through 1976, there will have been delivered 168,792 open-end spinning spindles into this country . . . To date, the open-end spinning that is in operation, together with that available for delivery in the next two years, is limited in capacity to 1″ to 1½″ fiber lengths, generally, with a small portion have the capability of up to 2″. The industry has been demanding longer staple capability for many end uses, but as yet, only prototype or mill-trial equipment is available. Again, this modification should be available in mid-1975 for mill installation . . . Without exception, all of the major machinery manufacturers

are in process of stepping up their rates of production of this particular equipment, and the best estimate available is that, in the several years after 1976, open-end spinning will come into the country at approximately 60,000 spindles per year, which is at a rate of $60,000,000, annually, for that period." (p. 16-17) (The reasons for the development of Open-End Spinning are "technological and economic obsolescence." ATMI assesses the influence of this development as "major." It projects "future developments (next 5 years)" to include "Open-End Spinning from Card Sliver," a "major influence" which would replace the Drawing process. (p. 18) ATMI also projects "Long Staple Open-End Spinning" in the next 5 years, with a "major influence" in replacing Ring Spinning through an extension in the yarn counts suitable for processing under the new system. (p. 18)

The above-cited ATMI report was prepared in response to a request by the Office of Industrial Economics, U.S. Department of the Treasury which announced a study of the textile industry in April 1974 as part of its evaluation of the existing asset depreciation system. The facts developed by the industry were further supported by a report by W. D. Cooper which the Department commissioned.[28]

Cooper's study confirms the fact that "during the 1960's and 1970's textile machinery advancements have been accelerating and are expected to continue into the 1980's." [29]

Cooper finds "marked productivity increases across the board" in Opening through Spinning processes during the 1960-1970 period.[30] "During the late 1960's and early 1970's" he reports "the trend in the card room was towards high production carding, chute-fed materials, a reduction in card room and blow room personnel . . .

(M)uch of the new chute-fed carding equipment purchased during the 1967-1973 period was imported, and because import data lumps all yarn preparation machinery together, it is difficult to measure the impact of imported carding during this period." [31]

Among the "major post World War II technological changes" identified by Cooper, "non ring-spun yarns" are anticipated to have "a profound effect as a substitute technology for conventional ring-spun technologies . . ." [32] In 1974 the market for yarns suitable for production by rotor open-end yarns represented a potential 1.3 million open-end positions, or about 17 percent of the U.S. yarn market. One open-end machinery manufacturer estimated that the number of open-end positions in the United States would grow from 46,544 at the end of December 1974 to 230,000 positions in December 1976 but Cooper judged this as "probably too high a forecast due to economic conditions of 1974-75." [33]

The Treasury Department's investigation of textile technology yields the following data relevant to the present proceedings:

> (1) A sample survey taken of textile companies with 45% of the textile industry's total assets projected 1975-80 capital expenditures in the Yarn and Thread areas to comprise 29.6% of the total of such expenditures, compared to 10.4% and 9.8% in the 1958 and 1972, respectively.[34]
>
> (2) ". . . the projected growth in yarn formation machinery probably means many companies are investing in open-end spinning equipment. At present, open-end spinning machines still have some limitations in yarn deniers but have high production capabilities and are labor saving. Open-end spinning combined with a completely automated fiber opening and carding system can replace eight conventional

processes with two. The obvious savings in labor which is reportedly hard to obtain, is probably a major reason why a significant increase in yarn formation investments are being forecast." [35]

(3) "OIE believes . . . that it must consider such items as the sources, availability, and requirements of capital in determining the expected future asset retention and repair practices of an industry or activity.

"In the above context, a shortage of capital funds might indicate that an industry, such as the textile industry, might not replace certain assets as rapidly in the future as it has in the past. Conversely, the need to meet OSHA and EPA standards might force the industry to replace other assets more rapidly than in the past.

"Therefore, capital requirements, availability, and sources were additional factors utilized in the determination of the recommended guideline depreciation periods and the guideline repair allowance percentage." [36] (It should be noted that the Treasury Department in 1976 reduced the guideline period for Class Life Asset Depreciation for yarn, thread and woven fabric assets from 14 years to 11 years as a result of this study, with a permissible range of 9 to 13 years.)

(4) "Over the past eight years open-end rotor spinning was perfected for selected yarn counts. Mills which installed these new spinning machines as part of a completely automated system replaced eight conventional yarn formation operations with two. Also, depending on the type of yarn count manufactured, open-end rotor spinning produces two to five times more yarn per pound per machine than conventional ring spinning. As a result, yarn mills are reported

to realize substantial savings in labor, floor space, production time per unit, time and quality control . . . machinery manufacturers are reportedly increasing their capacity to produce such machines . . . The demand in open-end rotor spinning machines will continue for the next ten years and is expected to account for more than one-third of the spun yarn output by 1985. This trend is corroborated by OIE's survey which reports major investments in yarn formation machinery and equipment over the next five years." [37]

(5) The weighted average life of depreciable assets used to manufacture spun yarn and thread is projected to decline from the historic level of 17.83 years to 8.80 years, according to the Treasury Department survey of the industry.[38]

(6) "A 20% reduction in the asset guideline period for this class is mainly justified by placing a major emphasis on events which will continue to force weavers and spinners to make substantial replacements of outmoded machinery with more modern equipment and processes . . . This change to the newer technology is reflected in the tripling of anticipated investment in yarn and thread manufacturing assets over the next five years, implying substantial replacements over the near future. The rate of change to the new technology is also expected to accelerate as new and better open-end spinning machines are introduced in the market place. . . Other investments are also anticipated for enclosed chute fed fiber systems. . ." [39]

It is evident from the above reports by the ATMI, the North Carolina State University School of Textiles and the U.S. Treasury Department that significant process modifications and machine design changes are expected to have increased impact in the immediate future, par-

ticularly in relation to the need for complying with government dust standards.

3. *Data from OSHA Compliance Inspections*

In order to obtain additional information on the role which advanced technology has been playing in the task of reducing dust emissions in textile mills we have made inquiries of OSHA at both the federal and state levels. At our request Mr. Cois M. Brown, Assistant Regional Administrator in the Atlanta regional office of OSHA, has furnished us with a report on eight cases of textile plants which have been the subject of compliance inspections by area offices of OSHA. Since these cases are involved in various stages of the enforcement process, Mr. Brown declined our request to identify the companies involved. A copy of Mr. Brown's letter of January 27, 1977 with enclosed reports on eight cases is attached as Appendix 6.

Of the eight reported cases, three have not been subjected to follow-up inspection so the results are not possible to evaluate. (Cases 2, 3 and 4) In two cases, follow-up inspections reveal reduced dust levels but abatement efforts are still under way (Cases 5 and 6).

In the three remaining cases (No. 1, 7 and 8) full compliance with the present standard has been achieved. It is noteworthy that in each of these three cases process modification or machine design change has played a significant part in achieving compliance:

> In Case No. 1 the installation of chute-fed cards eliminated the picking operation (with dust levels of 3.5 and 3.38 mg/m^3 OSHA personal samples.) The resulting dust levels in Carding (0.42 and 0.36) are equivalent to approximately 200 ug/m^3 vertical elutriated dust.

In Case No. 7 controls implemented prior to OSHA inspection include direct feeding of stock from Opening to Carding, chute-fed cards and open-end spinning. The dust levels recorded in carding and spinning (0.38 mg/m^3 and 0.13 mg/m^3 respectively) are well within the proposed limit of 200 ug/m^3 vertical elutriated dust.

In Case No. 8 controls implemented prior to OSHA inspection included "sufficient enclosure of (carding) machine to aid in dust collection." The dust level reported in carding (0.85 mg/m^3) is well below the present standard of 1 mg/m^3.

The above data compiled by the Atlanta regional office of OSHA provide further support for our observation that the failure of RTI to make provision for including process modification and machine design changes among the means of achieving compliance with the proposed standard represents a serious error.

Further evidence to demonstrate this point is submitted in Appendix 7 (Process Modifications and/or Machine Design Changes Reported at Plants Inspected for Cotton Dust by North Carolina Occupational Safety and Health Administration.) The plants covered by these reports vary from small to large, from independent yarn mills to integrated chains. They all share one characteristic: when confronted with the need to reduce dust to comply with the OSHA standard they have found advanced technology an efficient and economical means of meeting the challenge. It has been the Union's experience in dealing with companies with which we have collective bargaining relations that in case after case involving exposure to excessive cotton dust the most effective means of abating the hazard has been through process modification or machinery design changes.

4. *Data from Technical Reports*

As noted in *America's Textiles* magazine, "the chief stimulus for mill buying of preparatory and carding

equipment is dust control to meet OSHA standards . . . every time OSHA issues a citation to a mill for excessive dust, equipment builders receive a flurry of new orders for machinery and equipment to reduce dust." [40] However, abatement of OSHA violations is not the only motive:

> "The second most important stimulus is higher production and lower costs, especially by replacing lap-fed conventional cards with chute-fed high producduction cards to reach production rates of 50 to 60 pounds per hour.
>
> "In most mills, these two results, dust control and lower costs, are obtained in a single move . . ."

It is evident from a review of the journals dealing with developments in textile technology that the firms which have adopted advanced technology to abate dust problems have reaped the benefits of cost reduction and quality improvement as well. The following excerpts from representative articles, which are attached as appendixes, illustrate the nature of the savings involved:

> *"Mill Men Stress Spending in 'Basics'*
>
> "Mill officials point out that in many cases it is impossible to differentiate between environmental and non-environmental equipment spending. Investment in chute fed, high speed carding, in drawing, in automatic fiber feed systems in the opening room where the process of transferring raw cotton and synthetic fibers into hoppers have been mechanized, has been made with an eye as much to production and quality as to the environment." (Appendix 8)
>
> *"New Bale-O-Matic System Reduces Dust Level*
>
> "It is reported that with the cost reductions and improved quality due to blending, the complete Bale-O-Matic System can show a 25%-30% return on investment." (Appendix 9)

"*Preparing and Carding 1975*

"Both chute feeding and enclosed high production cards began as economy and labor availability moves. But the impact of OSHA dust and fly control requirements has pushed this consideration to the top." (Appendix 10)

"*OSHA Cotton-Dust Standard a Time Bomb for Textiles*

". . . in opening and carding, mills have been able to gain some production advantages in most cases while cleaning up the air. In going to high-speed carding with air-return systems, they have gained production while reducing costs." (Appendix 11)

"*OE Flood The Mills*

"Conventional estimates are that OE Spinning can reduce the man-hour requirement in yarn preparation by half to a third compared to ring spinning. The labor saving results from elimination of at least one processing step, roving; a reduction in doffing frequency . . . and in some cases elimination of rewinding.

"In addition, an all-OE spinning plant is noticeably cleaner." (Appendix 12)

"*Energy Questions in Spinning*

"The overall costs in OE spinning are nearly 5% lower than in ring spinning (Tables I and II)." Table I shows the cost of ringspinning 1-inch staple length, 50 tex (Nm 20 = Ne 12) as 1.568 Swiss francs per kg. Table II shows the cost of OE spinning of the same yarn as 1.494 Sw. fr. per kg. (Appendix 13)

It is evident from the above that it makes economic sense for textile companies to utilize the best available

technology to meet the OSHA cotton dust standard. Firms that have been the subject of enforcement actions have had a pressing reason for doing so. Moreover, a number of companies have made public announcements reflecting recognition of the fact that a progressive policy of modernization is in the financial interest of the company as well as in the interest of protecting worker health.

5. *Data from Company Reports*

Burlington Industries, Inc., the largest textile firm in the country, announced in its 1976 Annual Report that "concern for our employees' health can be seen in investments the company makes that modernize our plants and also increase productivity. Major installations of chute-feed cards have been made throughout the company to reduce the dust that previously resulted from the opening and blending of fibers." The company added the following announcement:

> "To eliminate the dust usually present in the opening of cotton bales, automated cotton handling equipment and chute-feed cards have been installed at many plants. By 1980 all of Burlington Industries' spinning operations should be equipped with these modern dust control devices." (Appendix 14).

A medium-size textile company (Russell Corporation, with sales of $103 million) made the following observations in its 1975 Annual Report:

> "Russell's ongoing plan improvement program is designed to introduce new technology into the production facility as it becomes available, to improve productivity, lower costs, improve customer service and product quality, and maintain the flexibility of the plant. Management believes it is the responsibility of American industry to keep pace with ad-

vancing technology to remain competitive in domestic and world markets. Plant improvements are also intended to improve environmental conditions for employees and the community.

"During 1975, the automation of card rooms at two of the Company's yarn manufacturing plants was completed. This streamlining included automatic opening and chute fed cards, resulting in virtually dust-free working conditions. New open end spinning frames were also added at the Coosa Plant, increasing productive capacity by 25 per cent, while reducing costs." (Appendix 15)

The following excerpt from a smaller textile company (American and Efird Mills) makes a similar point succinctly:

"The planned capital expenditures of $3,405,000 for fiscal year 1977 and $1,981,000 for fiscal year 1978 are primarily for improvements in sales yarn operations, which will increase productivity, meet certain OSHA dust standards and achieve significant labor savings in the manufacturing process." (Appendix 16)

Inasmuch as the more modern processing equipment is designed to achieve maximum enclosure and generally incorporates built-in cleaning devices which minimize dust emissions, the levels of dust to which employees are exposed can be readily controlled. Thus, Dr. Harold R. Imbus, Burlington's Medical Director, reports that the average dust level in the carding department of a spinning plant he studied declined from 2.06 mg/m^3 elutriated dust before installation of chute-fed cards to 0.315 mg/m^3 afterwards. In fact, he reports that the latter level "is an average of the two areas in the room," i.e., areas in which some of the old and the new cards were operating. According to the author, "further reductions

in dust will occur when the (chute-fed card) installation is complete." [41]

In another plant reported in the same study, Imbus finds a range of 0.07-0.93 mg/m³ of elutriated dust in a card room with "modern cards of chute feed type." While no time weighted average is reported the exposure is characterized as "generally between 0.2 and 0.5 mg/m³." It is also noted that "a rather low grade of cotton is used." [42]

Similar findings are reported by Neefus in a study of dust monitoring with a vertical elutriator and the GCA dust monitor.[43] He reports the following comparisons of dust levels between Old Cards and Chute-fed Cards using the GCA:

	Plant A		Plant B	
	mg/cu m	(n)	mg/cu m	(n)
Old Cards	0.44	(4)	0.87	(3)
Chute-fed Cards	0.19	(4)	0.66	(3)

He also reports on an effort to "evaluate whether open-end spinning was as dusty as ring spinning." The following data are given for a spinning mill using 50/50 polyester/cotton:

	Open-end Spinning	Ring Spinning (VE)
	(mg/cu m)	
$\bar{x}$	0.19 (n=8)	0.28 (n=42)
x_m	0.17	0.17

Neefus reports that the correlation coefficient between the vertical elutriator and the GCA is quite high ($r = .87$) and that the two agree up to 0.7 mg/m³. Consequently, the above comparison indicates a significantly lower dust level for open-end spinning. Indeed, the average dust level for open-end spinning is well within the proposed limit of 200 ug/m³.

6. *Data from Union Observations*

These findings are consistent with the observations made by the Occupational Safety and Health Director of the Union in May 1976 when he visited four plants of Burlington Industries, Inc. The Corporate Medical Director and the respective Plant Managers furnished us with the results of environmental monitoring (vertical elutriator and total dust) and reviewed the modernization programs which had been instituted in each of the plants. With the exception of occasional malfunction of particular equipment, it was noted that total dust levels in each department were within the present permissible limit of 1 mg/m^3.

The most striking fact noted in this survey was the correlation between advanced technology and the degree of dustiness. The Flint Plant (Gastonia, N.C.) which had been modernized most recently, had automatic opening and direct feeding to chute-fed cards, with effective built-in ventilation. Dust levels in this plant varied between 0.10 and 0.21 mg/m^3 elutriated dust, with only two of the 12 operating areas recording more than 0.20 mg/m^3.

Environmental monitoring of the other plants (Erwin, Mount Holly and Smithfield, North Carolina) provided management with an indicator of the areas where further technological improvement was required. The Plant Managers reported that the substitution of advanced technology had generally reduced unit costs of production since the new equipment was much more highly productive than conventional equipment. These reports were consistent with the information obtained in discussions of this subject with various other managements.

The cost-saving character of the new technology is further demonstrated by a report of the Kurt Salmon

Associates, a leading management consultant firm serving the textile industry.[44] This study shows that a cotton mill utilizing the latest technology in use as of 1975 would operate at a lower unit cost of production than a mill producing the same product on the basis of the 1967 technology, even after taking into account increased capital costs. Consequently the 1975 model mill would generate 12 percent more net profit and 66 percent more cash flow than the 1967 model.[45]

The text of the report by the Kurt Salmon Associates is attached as Appendix 17.

A research project currently under way at the Georgia Institute of Technology which has developed an improved packaging system for cotton, is illustrative of the technological potentialities which are on the horizon. Under this prototype system raw cotton has been packaged at the gin by means of vacuum densification so as to reduce "the exposure of workers to byssinotic agents" and to provide "simpler opening procedures which can be integrated with present pneumatic chute feed systems." [46] A copy of the 1976 annual report of this project is attached as Appendix 18.

Assessment of the feasibility of any standard must contain a degree of speculation. We are not privileged to foresee the future. The effort which the Research Triangle Institute made to do so was based on a set of assumptions. The critical assumption was that textile technology would remain frozen and that the industry would have to rely on retrofitted ventilation devices to meet the new standard.

We have demonstrated that this assumption is unrealistic in the extreme. It flies in the face of the actual experience of the industry in seeking to reduce dust levels to meet the existing standard. Technological advances which have automated the manufacturing processes and

enclosed the operations so as to minimize the emission of dust have been utilized before applying ventilation. In this way the cost of dust suppression has been offset by the savings from higher productivity. The task of meeting the proposed standard is therefore feasible in economic as well as technological terms.

* * * * *

EXHIBIT 78, APPENDIX 5

* * * * *

The starting point in this analysis is the use of the dust concentration survey carried out at the breathing zone of the operators to identify the problem areas in the cotton mill. Priority in the treatment of problem areas is given to the early stages of cotton processing areas where the dust-concentration level is the worst. This is due to the urgent need for correcting the situation and to the fact that any reduction in the dust concentration in this area may, in general, bring about corresponding reductions in most of the other problem areas.

* * * * *

EXHIBIT 78, APPENDIX 15

Excerpt from
Russell Corporation 1975 Annual Report

IMPROVING FACILITIES

Consistent with the Company's commitment to continuing plant modernization, a two-year $15,000,000 capital investment program was undertaken in 1975, with some projects completed in that year, and others scheduled to go on stream during the current year.

Russell's ongoing plant improvement program is designed to introduce new technology into the production facility as it becomes available, to improve productivity, lower costs, improve customer service and product quality, and maintain the flexibility of the plant. Management believes it is the responsibility of American industry to keep pace with advancing technology to remain competitive in domestic and world markets. Plant improvements are also intended to improve environmental conditions for employees and the community.

During 1975, the automation of card rooms at two of the Company's yarn manufacturing plants was completed. This streamlining included automatic opening and chute fed cards, resulting in virtually dust-free working conditions. New open end spinning frames were also added at the Coosa Plant, increasing productive capacity by 25 percent, while reducing costs.

The weaving operation is undergoing modernization with the initial installation of new high speed wide looms, the first new looms installed in the plant since the 1950's. The new equipment will produce wide goods at increased speeds, improving both productivity and the diversity of end products. Installation of the new looms, under Phase I of the program, is underway at the date of this report.

The Company's two bleacheries are being consolidated in one location, reducing both operating costs and the expense of meeting environmental requirements. The consolidation will improve material flow and permit some interchange of equipment to accommodate the changing variety of products. All dyeing and finishing operations will be performed in one building, where knit dyeing and finishing capacities can be expanded as needed. An obsolete facility was vacated in the consolidation and its operations moved to the newer building.

A new wood chip fired boiler was completed and placed on stream earlier this month, providing substantial savings in fuel costs, plus decreasing the Company's dependence on scarce and expensive traditional fuels from outside sources. The area is rich in forest products and reliable supplies of wood chip products have been secured.

An important phase of the capital program is a new highly-automated distribution center, containing 250,000 square feet of warehouse and shipping facilities for finished products. It is designed to dramatically improve speed of customer order response, inventory controls, and production planning. The facility will be computerized and features the latest in automatic material handling equipment and systems. The center is scheduled for completion in the fourth quarter.

EXHIBIT 78, APPENDIX 16

AMERICAN & EFIRD MILLS

[Emblem]

Excerpt from 1976 Annual Report

Business

A & E is a major producer and merchandiser of sales yarns and sewing thread. Its yarn products include a wide range of combed cotton, synthetics and blends, worsted system and dyed yarns. Yarn is sold to weavers and knitters of both underwear and outerwear. Thread products include cotton, spun synthetic and filament threads which are sold to apparel, automotive, furniture, shoe and packaging producers throughout the U.S. and certain foreign markets.

The company's objective is to operate as an innovative, low-cost, diversified producer and marketer in both its Yarn and Thread divisions. It manufactures virtually all of its products which are sold through its direct sales organization.

Most aspects of the yarn business tend to be highly cyclical as dictated by fashion, a more limited range of customers and economic conditions. Thread operations are characterized by more consistent demand requiring greater service features to a number of large customers.

1976 Operations

A & E entered fiscal 1976 in an economic environment that showed marked improvement over that of the prior year. Sales in the first quarter were up 48%. This improvement occurred mainly in the thread operation where economic activity created a strong demand for these products. Record levels of sales and earnings in the

Thread Division continued throughout the fiscal year. While the Yarn Division showed significant improvement in both sales and earnings, not all plants operated at capacity for the entire year. This was attributable both to weakness in demand for some sales yarn and to mill modifications that were made in order to realign capacity for more emphasis on cotton and cotton-polyester products. Each succeeding quarter in fiscal 1976 produced an increasingly better result and as the year ended the Yarn Division was operating profitably and the Thread Division continued to perform at gratifying levels.

Capital expenditures completed during 1976 were for the expansion of core-thread capacity, the improvement of thread finishing, and the realignment of certain sales yarn plants to more profitable product lines. At the close of the fiscal year plans were underway to convert the unprofitable textured yarn operation to a filament processing plant for the Thread Division.

Outlook

Thread operations should continue its good performance in 1977. The efforts to concentrate sales with the larger accounts have succeeded thereby providing an increase in sales volume and a more predictable and continuous demand. This has allowed better planning, reduced inventories and overall has allowed for a more profitable operation.

Yarn operations, while greatly improved, continue to suffer from erratic demand. It is anticipated that yarn sales will return to more normal levels in the near future, resulting in further improvement in Yarn Division profitability.

The planned capital expenditures of $3,405,000 for fiscal year 1977 and $1,981,000 for fiscal year 1978 are primarily for improvements in sales yarn operations,

which will increase productivity, meet certain OSHA dust standards and achieve significant labor savings in the manufacturing process.

Employees 2500.

	(Dollars in Thousands)				
Five Year Summary	1976	1975	1974	1973	1972
Net Sales	$78,586	$52,943	$72,661	$69,426	$65,271
% Total Ruddick	27.9%	23.1%	32.7%	36.8%	37.7%
Operating Income (Loss)	$ 3,723	$(1,592)	$ 4,825	$ 2,600	$ 2,900
% Total Ruddick	37.6%	(34.8)%	47.6%	47.2%	48.8%
Average Capital Employed	$34,726	$33,714	$33,439	$32,369	$31,445
% Total Ruddick	58.2%	53.6%	62.3%	65.5%	65.7%
Operating Return on Capital Employed	10.7%	(4.7)%	14.4%	8.0%	9.2%
Depreciation	$ 1,869	$ 1,808	$ 1,733	$ 1,733	$ 1,660
Capital Expenditures	$ 2,263	$ 2,034	$ 998	$ 1,291	$ 3,238

EXHIBIT 79a

Summary Statement of Parker C. Reist and Lawrence D. Kornreich,

"The Impact of New Production Equipment on Control Costs to Meet the Proposed Cotton Dust Standard"

In preparing the proposed cotton dust standard, OSHA relied heavily on an inflationary impact statement prepared by the Research Triangle Institute. In this report, control costs were estimated by extrapolation to the dust concentration required from known control costs at higher concentrations. But it is possible that actual costs could be much lower if state of the art production technology is considered. Much of the production machinery now in use is quite old and was originally designed with little consideration for dust emission. At present dust emissions are considered in designing and installing production equipment. It is possible that with the modern machine designs and higher production rates now available, control costs to meet a recommended exposure limit of 0.2 mg/m^3 will be lower than estimated by OSHA.

We report on the results of a study of control strategies associated with new manufacturing equipment as compared to conventional manufacturing equipment. Most of the information that has been developed pertains to carding, although automatic opening devices are often associated with high speed cards. Less information is available which pertains to spinning.

There are two principal reasons why the cost of control should be lower if a mill converts to newer equipment: 1) The operating cost of new equipment with controls on that equipment is less than the operating cost of the old equipment with controls necessary for the older, slower equipment to meet proscribed dust levels; and 2) by going to newer equipment with controls there is

a liklihood that increased production rates will result in recovery of some or all of the capital cost of control. This would be impossible with controls just added to present production capacity.

Considering carding as an example, the amount of ventilation required for equivalent dust control between old and new production processes remains essentially constant while the production rate (pounds of cotton processed per machine per hour) rises with new and rebuilt machinery. This conclusion is reached based on surveys of production rates and air flow requirements for several cotton mills which have undergone card modification as a means of achieving lower dust levels. For these mills the range of air flow required per card varied from 800 cfm to 820 cfm while production rates varied from 18 lbs. per hour to 70 lbs. per hour. Thus it appears possible that replacement of older, slower cards by higher speed units will increase production without additional air volume requirements, or conversely, the same production rate can be maintained with significantly smaller air flows needed. This means a rather large savings in total volume required to achieve the same total production rate. We recognize that it is not always possible to use high speed cards for all grades of cotton. For example, high quality long staple cotton fibers can be broken with a reduction in cotton quality if carded with high speed cards. This high quality cotton, however, is the cleanest raw cotton available, and so presents the least dust problem. Serious dust exposures are more likely to occur when processing low grade cotton, which can be processed with high speed cards.

It is clear that there are some capital savings to be obtained by going to higher speed equipment in terms of less expenditure for control equipment. This is summarized in Table I and graphically illustrated in Figure 1, where it is seen that air volume requirements per pound of cotton decrease as the production rate increases.

Another possibility is that by utilizing higher speed equipment and increasing production rates some of the cost of control can be recovered, since additional capacity can be purchased by replacing old equipment with new equipment for a very small increment of cost. By strictly replacing older cards with newer cards, and only matching capacity, there is no possibility of obtaining any return on the investment made in new equipment plus controls.

Although the stimulus for making changes in production equipment is likely to continue to be changes in, or enforcement of, standards of exposure to cotton dust. There are other benefits that accrue to the mill from the change as well. The mill becomes cleaner. In all cases investigated of before and after studies in opening rooms, picker rooms, and carding rooms there was an improvement (often a dramatic improvement) in going from older equipment to new equipment.

We recognize that there are a number of factors besides equipment replacement which must be considered. Sometimes additional air conditioning is needed. Sometimes the plant layout needs to be modified as well, to minimize the passage of dust from one room to another. Nonetheless the net result has been a cleaner working environment. The impact of this cleaner environment on the overall product quality, coupled with any production changes that could cause changes in quality, is hard to assess. However, the pattern of new equipment use in major mills to meet dust standards suggests that utilization of newer, more modern equipment offers the possibility of many benefits for management while providing a healthy environment for the workers.

EXHIBIT 79c

Reist, *et al.*, "The Impact of New Production Equipment on Control Costs to Meet the Proposed Cotton Dust Standard"

Introduction

A number of studies in the United States and other countries have demonstrated that persons working with vegetable fibers, and especially cotton, develop an occupational disease characterized by shortness of breath, tightness in the chest and general respiratory insufficiency. The disease, which can be disabling, appears to be caused not by the cotton fiber or fly, but by finely pulverized cotton plant parts such as the bract. This cotton dust, which is entrained in the raw cotton by mechanical picking, is released during the processing of the cotton into textiles.

There is still debate as to a "safe" level of exposure to cotton dust. Early workers recommended a level of 2.5 milligrams per cubic meter (mg/m^3) for total dust and the 1966 American Conference of Governmental Industrial Hygienists TLV list recommended a value of 1 mg/m^3 total dust. More recently investigators have found closer correlation of disease prevalence with the middle size range of the dust rather than with the total dust (1,2) and samplers have been designed which sample this middle range. Since only a fraction of the total dust would be measured by these samplers, in 1972 the ACGIH Threshold Limits Committee proposed changing the LTV for raw cotton dust from 1 mg/m^3 total dust to 0.2 mg/m^3 of lint-free dust, as measured by the vertical elutriator (3). This TLV has been adopted by the ACGIH and is presently the recommended level (4). The current Occupational Safety and Health Administration standard is 1 mg/m^3 total dust, based on the ACGIH TLV of 1968.

There have been a number of criticisms of the studies from which these recommended levels arose, not only based on arguments of faulty epidemiology, but also based on arguments of excessive costs to meet these lower dust levels (5).

The purpose of this study was to investigate various control strategies associated with new manufacturing equipment as compared to conventional manufacturing equipment. Much of the production machinery now in use is quite old and was originally designed with little consideration for dust emission. At present, dust emissions are considered in designing and installing production equipment. It is possible that with the modern machine designs now available, incorporating higher production rates, labor savings, and improved product quality, control costs to meet a recommended exposure limit of 0.2 mg/m^3 as measured by the vertical elutriator will be lower than previously estimated.

The textile production process is very complex, involving a number of distinct manufacturing steps. We have chosen for the purpose of illustration the dustiest of these operations, that of the opening of the incoming new cotton fibers at the yarn mill and the carding of this cotton. It is possible, however, that an analysis similar to that presented here will also be applicable to other production steps such as weaving.

The Opening and Carding Process

As it arrives at the yarn mill, raw cotton is a tangled mass of fibers, tufts of fibers and pieces of leaf, motes, dirt and sand. To be produced into yarn much of this trash must be removed and the fibers aligned as a roughly parallel bundle of fibers known as the sliver. The opening and carding operations convert the raw cotton into a continuous sliver for further processing (6).

Cotton bales are opened and can be either manually or automatically fed through a blender to the opener. In the openers the raw cotton is subjected to various types of beaters and/or saw cleaners to loosen tufts of cotton and allow heavier dust and dirt to fall out. The opened cotton then is transported to a picker where further opening takes place. The processed cotton is mixed up in this operation and more of the trash and short fibers in the cotton are removed. The picker forms a uniform lap which can then be fed to the carding machine. With high speed cards the picker is eliminated and the opened and blended fibers are fed as small tufts of fibers directly to the card feed via a chute.

As mentioned earlier, the cards align the fibers by opening and straightening out the tufted cotton fibers delivered to it. This process, which if fairly vigorous, not only can release dust contained in the cotton tufts, but also may crush trash particles to produce smaller particles. The cotton card is the main dust producer in a cotton textile mill.

The first mechanical card was built in 1748 and was improved by Arkwright, Smith and others until a machine in the mid-nineteenth century evolved which looked very similar to ones manufactured up into the 1960's (7). Production rates of cards also remained relatively unchanged for almost 100 years until the introduction of the so-called "high-speed card" in the 1960's (7). With the high-speed card the loading on the cylinder is reduced and the transfer ratio of the fibers from the cylinder to the doffer is increased. As this transfer ratio improved, the fibers spend less time on the cylinder, reducing the possibility of neps. Decreasing the loading improved the carding action and hence quality (8). There has been fairly rapid conversion to these high-speed cards within the textile industry when the savings in money and labor was recognized. In 1975 the ATMI

could report that 80 percent of the total weight of cotton carded in the United States was carded on high-speed cards (9).

High-speed cards have not evolved in one single step, however. It has been a continuous process where production rates attainable today were not possible as few as two years ago. In fact, many of the cards considered to be "high-speed" by the ATMI in their 1975 survey would be definitely "low-speed" today. In 1966 high-speed or high production carding was considered to mean carding at rates of 20 to 40 pounds per hour (lb/hr) (8) compared to the then conventional rates of 6 to 12 lb/hr (10).* The industry actually could be considered to now be on the second generation of high-speed cards, with current commercially available units capable of production rates of 80 to 120 lb/hr (11). This is contrasted to 1973 when most cards operated at speed of 40 lb/hr or less (12).

Dust Control

Dust and fly generated in the production stages from feeding the bales through carding consists of both relatively large material of no importance from a health standpoint, but being valuable as a waste material, and relatively small particles which have no economic value but appear to be the causative agent of bysinnosis. Local exhaust ventilation is used to handle both types of dust.

Exhaust ventilation, as used for dust control, relies on providing a sufficiently high flow of air past a particle so that it abandons its state of rest for one of motion. The air then acts as a conveying fluid to transport the

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* Douglas Bowen writing in *Textile World* (December, 1976) states, in discussing rebuilt cards, "These cards usually run at relatively low speeds for today: 15 to 20 pounds per hour (6.75 to 9.0 kg/hr). As one small company's boss carder put it recently (with over 100 cards processing at 15 pounds per hour) (6.75 kg/hr), 'I'm happy.' "

particle to its final destination. The force necessary to encourage or control the motion of particles is that of the air currents and not the imaginary but often quoted "sucking power" of the fan. Thus the quantity of air required for ventilation would not be expected to depend on the concentration of dust in the air being removed, but rather on the dynamic properties of these particles in air.

How does this apply to high speed carding? First, although high speed carding often requires automated feeding, the amount of enclosure needed for the opening operations remains nearby the same for good dust control, whether work is carried out manually or automatically. Thus the ventilation requirements should be about the same for any raw cotton handling rate. The same should also be true for high speed carding. As machine speed goes up, particle throw will increase so that higher capture velocities (and air flow) will be required, but air volume requirements should not rise in direct proportion to the increase in speed.

Surveys of production rates and air flow requirements for several cotton mills that have undergone card modification as a means of achieving lower dust levels (13) confirm that the amount of ventilation required for equivalent dust control between old and new production processes remains essentially constant while the production rate (pounds of cotton processed per machine per hour) rises with new and rebuilt machinery. For these mills the range of air flows required per card varied from 800 cubic feet per minute (cfm) to 820 cfm while production rates varied from 18 lbs/hr. to 70 lbs/hr. Thus it appears possible that replacement of older, slower cards by higher-speed units will increase production without additional air volume requirements, or conversely, the same production rate can be maintained with significantly smaller air flows needed. This means

a rather large saving in total volume required to achieve the same total production rate. This is summarized in Table I and graphically illustrated in Figure 1, where it is seen that air volume requirements per pound of cotton decrease as the production rate increases.

We recognize that it is not always possible to use high-speed cards for all grades of cotton. For example, high quality long staple cotton fibers can be broken, with a reduction in cotton quality, if cardes with high-speed cards. This high quality cotton, however, is the cleanest raw cotton available, and so presents the least dust problem. Serious dust exposures are more likely to occur when processing low grade cotton, which can be processed with high-speed cards.

Much of the ventilation equipment on cards currently in use in the United States has been added after the machine was originally manufactured. These so-called exposed machines (14) presented great challenges to ventilation equipment designers to reduce ambient dust levels at a reasonable cost. It was recently pointed out that

TABLE I. VENTILATION REQUIREMENTS FOR CARDS AT SEVERAL PRODUCTION RATES

Mill Code	Airflow Per Card (cfm)	Processing Rate (lb/hr)	cfm per lb/hr
14	800	24	33.3
13	820	18	45.6
	820	35	23.4
8	1757	40	43.9
19	800	65	12.3
34	800	70	11.4
36	800	44	18.2

Although the majority of production cards existing in the textile industry today are low production "exposed" machines, recent technology has introduced

> higher speed production equipment which, by necessity, is more enclosed and hence more adaptable to ventilation control systems. These represent a very low number of cards in the industry, however. (14)

Economic Considerations

Under the pressure of rapid technological change, rapidly increasing labor costs and a shrinking labor supply, the textile industry has been shifting from a labor intensive to a capital intensive industry. (9).

Although the stimulus for making changes in production equipment is likely to continue to be changes in, or enforcement of, standards of exposure to cotton dust, there are other economic benefits that can accrue to the mill from the purchase new, state-of-the-art, production equipment. Much of the production machinery now in use is quite old and was originally designed with little consideration for dust emission. By going to newer equipment with controls, there is a likelihood that some or all of the costs of control could be recovered. This would be impossible with controls just added to present production capacity.

Increased Throughput

Because of the increased production capability of rebuilt, and newer second generation high-speed cards and open end spinning machinery, even with added controls it is possible to obtain a return of the capital investment. With these advantages, it becomes possible to recover the costs of attaching air filtering systems to production equipment.

> . . . in opening and carding, mills have been able to gain some production advantages in most cases while cleaning up the air. In going to high-speed carding with air-return systems, they have gained production while reducing costs. (15).

> During 1975, the automation of card rooms at two of the Company's yarn manufacturing plants was completed. This streamlining included automatic opening and chute fed cards, resulting in virtually dust-free working conditions. (15).

Lessened Operating Costs

In an analysis of a hypothetical greige fabric plant, the Kurt Salmon Associates study (16) reported the comparison of costs, using 1975 as a base year, of the then latest technology and conventional (1967) technology. Operating costs for the mill with newer cards and spinning were estimated to cost almost half of what it would cost to run a mill based on 1967 technology because of several factors, including the elimination of picking (by using high-speed cards) and roving (by using open end spinning), and the reduced maintenance requirements of both rebuilt and new cards. Even when air controls are added, the operating cost picture is still favorable. High-speed cards are able to be controlled with approximately the same air volume as conventional (low-speed cards), as noted in Figure 1. Thus, for a given amount of cotton processed, less energy is required to control the newer, faster machines compared to old cards of equivalent production capacity.

Claims of reduced operating expenditures come from several additional sources:

> It is reported that with the cost reductions and quality due to blending, the complete Bale-O-Matic System can show a 25%-30% return on investment (15).

> Some of the advantages [of automatic, chute fed cards] are:
>
> - Improved consistency of product quality, due to eliminating much of the reliance on human judgment and performance.

- Elimination of the picker and cost of the operation.
- Savings in floor space (26 to 38% for full automation).
- Elimination of lap transportation and storage.
- Reduction of labor requirements (25 to 50% for full automation).
- Better handling of "problem fibers."
- Elimination of lap waste at card feed.
- Reduction of card sliver breaks due to faulty lap joints.
- Longer life of card clothing because stock feeds fully opened.
- Elimination of double laps that produce irregular tufts at lickerin.
- Less curliness, fewer neps caused (18).

The higher cylinder speed in newer cards results in better separation of seed particles from the fibers and better overall quality. For example, with the Crosrol-Varga unit for high-speed carding an increase in the carding speed produces decreased waste with an increase in yarn quality (19).

Industry Examples

It is possible to examine the experience of several textile mills with respect to our arguments. These data were collected either through published information, review of public documents available in either North Carolina or South Carolina, or through private discussion.

Table II shows the amount of money spent by several mills in converting cards from either standard cards or first generation high-speed units, to second generation high-speed units. In all cases cited, one of the main rea-

sons for this conversion was to reduce dust levels, and in several instances the conversion was cited to indicate compliance with OSHA regulations.

Let us examine a specific example in more detail (17). Mill 5 contained 139 cards with speeds of 10 or 20 pounds per hour. This mill was faced with extensive dust control requirements. Three alternatives were examined. These were: 1) add more dust capturing equipment. This was estimated to cost about $2.8 million. At an assumed air flow of 800 cfm per card, this would represent air requirements of 40 cfm per pound of cotton per hour. 2) Use rebuilt cards with speeds of 60 lb/hr. Air flow requirements for these units are estimated to be about 1500 cfm per card (25 cfm per lb of cotton processed per hour). Capital costs would also be about $2.8 million but operating costs would probably be lower. 3) Replace the 139 cards with 32 new cards having speeds of 100 lb/hr. Assuming again the high air flow requirements of 1500 cfm per card, this would be equivalent to 15 cfm per pound of cotton processed. The estimated cost for this installation, including the addition of chute feeding, was also $2.8 million. Operational costs for this case were considered to be the least expensive of the three.

The choice was obvious. Although with all options, the capital investment did not decrease, Option 3, that with the lowest operating costs, also resulted in an increase in total carding capacity, from 2780 lb/hr. to 3200 lb/hr. In this instance, the capital expenditure for dust control resulted in increased productive capacity.

Ability to Meet Proposed Standards

There is little information available which compares dust levels to be expected with high-speed cards and appropriate dust control devices as opposed to dust levels found with conventional or first generation units. It is

difficult to compare data from one mill to another; and the installation of high-speed cards so alters the machine configuration in a card room that even before-and-after data from the same mill must be interpreted carefully.

TABLE II. NUMBER OF HIGH-SPEED CARDS REPLACING CONVENTIONAL CARDS IN MILLS SAMPLED.

Mill Code	Conventional Cards	High-Speed Cards	Was Dust Level Reduction a Primary Consideration in the Replacement Decision?	Cost of Replacement
1(A)	911	282	YES	$17,475,390[a,b]
(B)	417	82	YES	
(C)	1061	290	YES	
2	88	36	*	$923,870
3	54	12	YES	*
4	67	24	YES	*
5	139	32	YES	$2,800,000[a]
6	129	42	YES	$925,484
7	36	26	YES	*
8	108	21	YES	*
9	16	*	YES	$300,000
10	50	*	YES	$670,000

* Data not provided

a Includes air conditioning and other costs in addition to production and dust handling equipment.

b Total for A, B and C

Also, dust levels measured in one area may be the result of operations in another unrelated area.

Some limited data are available which indicate that use of high-speed cards with good dust control design can bring dust levels very close to the proposed standards.

The NIOSH Publication on Cotton Dust Control (13) describes a mill having 18 cards, each with a speed of 70 lb/hr. For dust control 800 cfm per card was used with a total of 18,000 cfm required for opening and cleaning. The total flow required, including an additional 800 cfm per card for the chute feed, is 37.1 cfm per pound of cotton processed. Designers of dust handling equipment for this mill anticipated a difficult control problem due to the high speed of the cards and the low grade of the stock being processed. This system was specified to clean up the visible lint and dust only. Surprisingly, the average dust levels (as measured by the vertical elutriator) in the card room were 0.34 mg/m^3 and in the opening room 0.30 mg/^{3}.

These levels are quite low considering that the air cleaning system was not designed for the fine particle removal. Dust capture appears to be adequate, and it would be expected that improved cleaning would reduce the average dust levels even lower.

Conclusion

Based on our examination of data already in print and interviews with control agency representatives, textile machinery manufacturers, and textile manufacturers, we summarize our finding as follows:

- Replacement of older, slower cards by high-speed units will incease production without substantial additional air requirements, or for the original production level, will reduce air requirements.

- For the same amount of money spent on controls for existing cards, additional capacity in newer, high-speed cards, also controlled, can be purchased.
- Significant operating cost reductions, coupled with increases in productivity as a result of using state-of-the-art technology, may result in a rapid payoff of equipment costs.
- Available information suggests that currently available technology can affect control of the workplace to meet the proposed new limit of 0.2 mg/m^3 elutriated cotton dust. There will be considerable waste in resources and effort if halfway measures are adopted instead of utilizing this best technology (automatic opening, second generation high-speed carding) in attempting to meet standards for acceptable dust levels.

EXHIBIT 80a

Statement of William A. Burgess

* * * * *

The feasibility of the proposed respirator use for protection against cotton dust depends principally on our knowledge of the protection one can expect from these devices and the extent to which they will be used by the workers. Let us first consider the matter of protection. The worker does not know how well the respirator is working unless he is a reactor and the wearing of the respirator reduces his pulmonary distress. The employer who purchases an approved respirator does not know the protection it affords the worker. The employer is provided technical information on respirators by the respirator manufacturers' sales representative. Does the sales representative know the level of protection afforded by the respirator? The representative is acquainted with the approval tests the respirator has passed, special studies his firm may have conducted, and certain respirator application guidelines, however, he does not know the protection afforded by the respirator against cotton dust in a given plant. It appears that no one knows the actual protection afforded by the respirator worn by the textile worker.

Some insight on the protection afforded by a respirator is available from respirator selection guides. These selection guides have been developed principally from work conducted by Hyatt at Los Alamos Scientific Laboratory (1). They are the basis for the Respirator Decision Logic of the Standards Completion Project and Table I (p. 56516) in this standard. The guides utilize protection factors as one criterion for respirator selection. Protection factor is defined as the ratio of the contaminant concentration outside the mask to that inside the mask. The protection factors were derived from tests conducted in a laboratory setting which met all require-

ments of the respirator program described in 1910.134. Do these tests reflect normal industry practice? Unfortunately, at this point in time they do not since few comprehensive industrial respirator programs meet all requirements of 1910.134. This statement can be supported by reviewing a series of in-plant studies on the effectiveness of respirators.

In an early study Caldwell and Schnell (2) evaluated the protection afforded by workers wearing oral-nasal masks in a uranium dioxide exposure. The authors concluded that "Air-purifying half face respirators are supposed to provide better than a factor of 10 protection. The computed average for the data shown is 2.1". This alarming report received little attention and has not been published in the open literature.

In a NIOSH sponsored study of respirator use in abrasive blasting (3), Blair has shown the large variability in protection encountered in the use of air supplied respirators. These devices are normally considered to provide excellent protection with a protection factor of 2,000.

> "Where air supplied helmets were used, protection factors from 1.9 to 3750 were noted. The remarkable range of these latter figures is attributable to the condition of the individual equipment rather than to any particular brand superiority."

Additional evidence of the limited effectiveness of air supplied hoods used in sand blasting has been provided by Samini et. al. (4).

A study of the paint spray industry (5) revealed that conventional air-purifying paint spray respirators provided an average protection factor of 3 for vapors and not the 10 one might anticipate from the protection factor tables. In the case of air supplied oral-nasal masks.

the observed protection factors ranged from 3 to 30, and not the 1000 cited in the guidelines.

In a study of dust respirator performance conducted by Eastern Associated Coal Co. in cooperation with the Harvard School of Public Health under a NIOSH contract the same pattern was revealed with lower protection obtained than predicted by application guides (6). A recent study of the in-plant respirator protection factors for protection against sulfur dioxide in copper smelters (7) shows that the protection afforded by three different oral-nasal masks was quite variable with mean protection factors of 22, 18, and 13. Although the mean values exceeded the guidelines protection factor of 10, the best mask had 30.4% of its tests with factors less than 10, and the worst had 56% with factors less than 10.

The protection factors proposed by Hyatt and used in Table I presume that a comprehensive respirator program is in place. This fact is stressed by Pritchard in his discussion of the application of respirator application factors (8). The studies I cited above represent what is happening in a variety of industries and what will happen in the cotton industry based on the provisions of the standard and its reliance on the general description of a respirator program in 1910.134. The proposed standard should be revised to provide specific requirements for a respirator program for the cotton industry including a requirement that the employer demonstrate the protection provided by respirators as worn in the plant.

The second issue identified in my initial remarks was the acceptance of dust respirators by the worker. With some reservation the standard accepts that respirators will provide significant protection and workers will be able to wear them routinely for protection against cotton dust. The best brief statement on this matter is that

made by A.J. Breslin an experienced industrial hygienist (9)

> "Industrial hygienists have long recognized the difficulties attendant on enforcing the wearing of respirators for long periods. Respirators are uncomfortable, impose resistance to inhalation, obstruct vision, and are somewhat encumbering. Because of these factors, workers are reluctant to wear respirators, and if the required periods of use are overlong, they may remove the respirators when not under direct supervision or wear the respirator loosely so that no protection is afforded. Time periods for which respirator use is tolerable vary with temperature, humidity, work effort and nature of the aerosol, but, in general, periods in excess of 1 hour are extreme, and it is preferable to hold times of use to 20 minutes or less. As a general rule, the use of respirators should be held to the minimum and carefully regulated."

In his testimony at the SCP hearing on the ketones, Held also stated that respirators could not be worn continuously "On many jobs, I recommended or required 15 minute coffee breaks every one to two hours while wearing a respirator rather than the usual mid-morning and mid-afternoon ones only" (10).

A foreign author has cited a case where workers with silicosis refused to wear respirators due to the inconvenience and loss of production (11). I have personally encountered this same situation in the asbestos insulation trades in the United States. My own rule of thumb is that an oral nasal mask cannot be worn continuously by a healthy worker for more than a one hour period without discomfort.

The reasons for poor acceptance of respirators has been detailed elsewhere but I do wish to consider one

factor determining respirator acceptance, namely breathing resistance. It has a special importance in this work population. The absolute values of inhalation and exhalation resistance and the ratio of the two values has a serious impact on acceptance of the respirator by healthy workers and even greater impact on those with pulmonary disability. The present U.S. standards for breathing resistance cited in CFR Part 11 in 1977 derive from arbitrary decisions made in the 1930's based on manufacturers' ability to meet a given specification rather than as a result of any physiological study (12). The limited number of studies of acceptable breathing resistance conducted since then have been, with one or two exceptions, conducted on young fit persons. The studies did not consider the response of the older worker with diminished pulmonary function. The absolute values of breathing resistance to acceptance are important and yet if you compare our standards with those of Britain, Italy and Germany you will find that ours are the highest. Low breathing resistance alone, however, is not the total answer. Silverman has shown that the ratio of exhalation to inhalation resistance is an important element in respirator design (13). He proposed that the exhalation resistance should be less than inhalation resistance unless both values are low. In valveless, single use respirators the inhalation and exhalation resistances are approximately the same. The impact of this design feature on acceptance has not been identified.

Breathing resistance was an important consideration in the specification of powered air-purifying respirators in the standard. I have designed a number of powered air-purifying respirators and I believe I have a balanced view of their application realm. The powered air-purifying respirator (PAPR) will, in the future, take a prominent position in respiratory protection but it will be on selected applications. The main contribution of

the PAPR is reduced leakage when used with oral-nasal, full facepiece and hood or helmet. If air delivery is adequate and the unit is equipped with an efficient air-purifying element these devices will provide protection factors equal to continuous flow air line equipment. One additional positive feature is the virtual elimination of inhalation resistance. Although inhalation resistance is negligible, the exhalation resistance of these devices used with facepieces is a function of the blocked tight static pressure of the blower and the resistance to airflow of the exhalation valve. It is therefore possible to have negligible inspiratory resistance and high expiratory resistance. This is counter to the recommendations of Silverman and its effect on persons with respiratory disability has not been evaluated.

The standard provides that a PAPR may be requested by the worker and this may also be a suitable substitute for transfer to a non-dusty job. In my opinion it is wrong to use the PAPR as an "escape hatch". To date there has not been a study of the use of PAPR in cotton plants, the positive exhalation resistance of the PAPR may be offensive to the disabled worker, the penalty of size and weight must be evaluated by the workers, and the present wording would permit an exposed population in excess of 300,000 persons to request a PAPR. At an estimated cost of $400.00 per unit and an annual maintenance cost of 100.00 this would represent an annual cost of 150 million dollars for these devices. This investment might be more positively applied to engineering controls.

For the above reasons I question the proposed application of PAPR in the standard. The availability of a PAPR may be a suitable substitute for transfer to a non-dusty job for certain workers but it will not be for all persons. I recommend that the workers be allowed an option—either transfer to a non-dusty job or

the use of a PAPR. My own personal view is that if the individual does have a respiratory disability a transfer is, in most cases, the better solution especially if one acknowledges the variability in protection afforded by all respirators including the PAPR.

* * * * *

EXHIBIT 82

Statement of Eric Frumin

* * * * *

II. *Respiratory Protection* (Section f)

The proposed standard would require the wearing of respirators by most exposed workers for at least seven years. The imposition of this requirement would be in violation of the Secretary's mandate under the Act to assure "the attainment of the highest degree of health and safety protection for the employee." Respirators cannot be considered to be a primary solution over a period as long as seven years.

In addition, there are several aspects of the respirator requirement which render it infeasible as a basis for a health standard:

A. Individual problems with respirator use

B. Worker resistance

C. Administrative problems in a Respiratory Protection Program (1910.134)

These will be discussed separately, followed by our recommendations concerning respirators.

A. *Individual Problems with Respirator Use*

In order to assure a proper fit workers must wear respirators which are tight to the point of discomfort. While some respirators are less troublesome than others, none can be considered as positively comfortable. The discomfort is often aggravated by the conditions of high heat and humidity which are often present in textile mills. The feelings of discomfort can also be aggravated if a worker has a common cold or other breathing or sinus interference unrelated to occupational exposures. The presence of dermatitis or other skin conditions may be exacerbated by the wearing of a respirator, and

workers often describe the irritating effect that respirators have on normal skin.

In addition to physical discomfort, workers subject to a respirator requirement undergo psychological discomfort which is at least as serious. Those who already suffer from claustrophobia certainly cannot wear a respirator comfortably. The wearing of respirators is objectionable to workers because of its disfigurement of their personal appearance. Moreover, it may require the alteration of one's preferred appearance (e.g., shaving of beards, etc.) Finally, respirators also interfere in one's ability to communicate. This is no small problem in an industry whose workers are already afflicted with the greatest noise hazards of any major industry. The further and unncessary deprivation of social contact on the job would represent a complete abandonment of the workers' right to be a liveable workplace.

Another major problem is poor fit. No single respirator can fit all individuals, yet it is a rare employer who can be relied upon to offer an adequate supply of different types of respirators to all affected employees. Those employers who do offer more than one type are generally unable to do the proper supervision to insure that the chosen respirator is appropriate to the individual's need.

Some problems with fit are simply beyond the control of an employer or his workers. Workers who wear glasses or dentures or have unusual facial structure may be unable to wear respirators under the best of circumstances.

If a properly tight fit is achieved, a non-powered respirator must of necessity interfere with the worker's ability to breathe. Additional proof is not necessary to demonstrate that significant numbers of the workers who will be required to wear respirators have already suffered some loss of lung function. Even the single-use, disposable respirator offers significant (though lessened) intereference. OSHA has recognized the seriousness of this problem by providing for the optional use of a

powered respirator. The technical impracticality of this "solution" will be discussed by Dr. Burgess. Suffice it to say that the final promulgation of this requirement would inflict cruel and unusual punishment upon those whose suffering was supposed to be eliminated by the passage of this law. Moreover, regardless of the regulatory options, the wearing of any respirator constitutes a hazard to the health of workers with decreased lung function, and must be avoided if at all possible.

B. *Workers Resistance to Respirators*

In view of the problems cited above, it is unlikely that workers will accept the wearing of respirators in large numbers. Worker resistance to respirator requirements is well known throughout industry, and will be the subject of additional testimony by ACTWU witnesses. Several aspects of this problem are worthy of detailed consideration.

One major reason workers will not wear respirators is because of the unfairness of placing the onus of such a sacrifice on them in order to achieve workplace health and safety. In the absence of an extensive employer commitment to hazard abatement, workers cannot appreciate the seriousness of the hazard. Training and education programs may attempt to fill the gap, but as the saying goes, "Talk is cheap." Unless workers see that all parties are seriously concerned with preventing byssinosis, they will not accept a disproportionate burden for themselves.

Also, wearing of a respirator may interfere with a worker's ability to work at normal speed. Without a mechanism for preventing any earnings loss for those who work on piece-rated jobs, workers often feel compelled to protect their earnings rather than encumber themselves with respirators.

Finally, the need for respirators is not always evident to the workers in a cotton-dust area. The initial symptoms may not be directly connected in the worker's mind to the actual dust hazard. The temporary nature of the initial symptoms leads workers to believe that there is little threat of chronic disabling disease.

C. *Administrative problems in a Respiratory Protection Program (according to OSHA regulation 1910.134)*

The proper administration of a respiratory protection program is a complex task, and requires a sophistication and dedication concerning worker health which are generally lacking in the textile industry. The character of hygiene programs in the industry will be described in more detail by the witnesses who will follow.

Among the more serious obstacles to proper administration of a respiratory protection program is the need for comprehensive training of supervisors in the use and maintenance of respirators. Time taken for such training as well as the actions suggested by such training are in direct contradiction to the supervisors' first concern—increased production. Furthermore, the supervisors' prevailing preference to enforce rules rather than to educate workers on the need for compliance make them less than receptive to the content of an appropriate training program. Finally, the extended period of time required for the administration of the program places great strains on whatever inclination a supervisor might feel to educate rather than enforce.

Another difficulty in administering a respiratory protection program is the necessity of educating workers in the need for the program and in the proper use of the equipment. In view of their normal resistance to the wearing of respirators, workers require an extended, thorough and repeated training program in order to

motivate them to comply with the program's rules. Such training can only be done during working hours, which creates anxiety about loss of earnings opportunities among workers on piece-rate jobs. Unless the quality of the training program is consistently maintained, workers will not feel a serious motivation to wear the respirator, and an enforcement mechanism will then become necessary. Once enforcement becomes the prime technique that the employer uses to assure compliance with the regulation, the Respiratory Protection Program is likely to fail. As stated by NIOSH in its *Guide to Industrial Respiratory Protection*, "Just throwing a respirator at a worker with orders that he wear it because OSHA says so is one of the easiest ways to ensure its misuse." (1)

Other obstacles to proper program administration are the requirements for adequate maintenance and storage. Most employers in the textile industry have little experience with such requirements despite the existence of regulations for the past six years. Furthermore, many manufacturing facilities are isolated and lacking sufficient numbers of workers to justify the hiring of a trained, competent safety director or industrial hygienist. Generally, respirator maintenance is left to management in a personnel office whose primary interest is assuring an adequate supply of labor for production purposes rather than providing workers opportunities to take time off for maintaining their respirators.

D. *The Proposed Requirements for Respiratory Protection Is Not Feasible*

The requirement for respiratory protection in the proposed standard is not feasible when applied to all workers exposed to excessive cotton dust over a seven year period. We have described the practical problems with individual fit and comfort and inherent limitations on workers' willingness to cooperate. Also, there are dif-

ficulties in the proper administration of a respiratory protection program even when the employer is making a good-faith effort.

These difficulties have been aptly summarized by C. M. Anglin, a NIOSH engineer, as follows:

> "The experience of the (Public Health Service) has been that respirators are sufficiently unreliable and unacceptable to workers to warrant the recommendation that they should be employed only as a last resort after all other feasible methods of hazard reduction have been tried. The unreliability of respirators can be due to poor face fit, inadequate maintenance and other factors that reduce the capacity of the respirators to filter the dust from the inhaled air. Worker rejection of face mask respirators that are supposed to be worn during the entire work shift is high and is one of the major failings of any respirator program. If the worker does not wear the respirator properly, he certainly will not be protected. Workers with impaired breathing function due to byssinosis or any other respiratory disease present a problem when wearing respirators due to the increased breathing resistance caused by the respirator filter. In some cases, this increased resistance is simply too great a task for the already impaired worker to endure.
>
> "It appears that respirators are not suitable for protection of textile mill workers in most instances." (2)

In the textile industry we have reason to doubt that the necessary good-faith effort by management will be forthcoming. While we cannot predict the future, the experience in the past does provide some guidance in this area. We have reviewed the files of all cotton dust inspections conducted by North Carolina OSHA in the

period 1975-1976. This survey reveals that in 100 opening, picking and carding departments visited by OSHA inspectors, only 15 were in compliance with permissible exposure limits for cotton dust. In those 85 not in compliance, the inspectors found that in 75 departments the respiratory protection programs were either non-existent or not in compliance with regulation 1910.134. Based on this experience, we feel it is unreasonable to expect that a respirator requirement is a feasible method of protecting worker health for the next seven years. The only solution to this problem is to reduce dust levels, as soon as possible, in order to eliminate the need for the wearing of respirators. Such a policy places the burden upon the employer, where it belongs.

E. *Recommendations concerning the Requirement for Respiratory Protection*

We have several recommendations concerning the final standard's provision for respiratory protection. First, we urge that the employer be required to consult with the employees or their authorized representative in the development of a written program. This is the most effective way to ensure that worker resistance to the rules for wearing respirators is minimized. Lacking such consultation, the employer is likely to establish a program in which the workers play a passive role, thus generating resentment tending to negate the effectiveness of the program. In particular, the employers must not be allowed to choose any particular respirators nor to develop any policies for management of resistant workers without allowing the workers a voice in those deicisions.

Furthermore, we urge the adoption of approved single-use, disposable respirators as an appropriate respirator for dust concentrations up to 2000 ug/m^3. These respirators have been recommended by NIOSH in the *Criteria Document.* Attached is a letter from the Chief of the

NIOSH Testing and Certification Branch reiterating that recommendation. From the workers' viewpoint, single-use respirators are preferable because of the lessened discomfort and resistance to breathing. This point was also noted in the Criteria Document. (3)

Finally, our recommendations for medical surveillance described below, will insure that a comprehensive program is undertaken to protect the workers' health, including the transfer of those workers unable to wear respirators. Such a program is essential to preclude the use of respirators as a long-term solution.

In view of the general preference for single-use, disposable respirators, we urge that employers be required to offer both the single-use, disposable respirator as well as at least one other air-purifying respirator suitable for concentrations below 2000 ug/m^3.

* * * * *

The fact is that there is a significant conflict of interest for any physician who diagnoses byssinosis in an active worker. If he makes the diagnosis, the employer is subject to claims for Worker Compensation. In view of the widespread prevalence of this disease, such claims cannot be considered financially immaterial. On the other hand, the diagnosis is obscured or denied, then the patient's health is placed at further risk. It is entirely inappropriate to the purposes of the Act to allow such a conflict to arise at all.

Furthermore, * * * the records of examination results often become the property of personnel offices. This transfer of records leaves the worker at risk of discriminatory treatment, including termination. Since most workers lack other means to protect themselves against such treatment, it is unreasonable—based on the record of this industry's performance thus far—to subject them to a continuation of these policies. The inevitable result will be the boycotting of the examinations by a large

number of workers, thus defeating the purposes of this provision. If it is the Secretary's intention that such examinations be made as widespread as possible, then it is his responsibility to protect the workers against the potentiality for abuse.

* * * * *

B. *Management of Byssinosis Victims*

A glaring deficiency in the proposed standard is the lack of definite guidelines for management of workers identified as suffering adverse effects from exposure to cotton dust. The standard calls for the Examining Physician to give a written opinion, including "any recommended limitations upon the employee's exposure to cotton dust or upon the use of equipment such as respirators." Further, the standard requires that a worker who cannot wear a conventional respirator be offered a powered, air-purifying respirator.

The latter proposal is an ill-advised attempt to avoid the questions raised by the omission of management guidelines. It is the omission itself which most seriously threatens the workers' health, and runs contrary to every principle of preventive medicine. Workers who are at risk of further damage must be given the right to transfer to a job in a less-dusty or non-dusty operation, without any loss in earnings or benefits, either present or future. To deny workers this right is to force them to choose between the slow, insidious development of byssinosis or the quick death of starvation. The choice will be obvious, and the purposes of the Act and this standard will have been defeated. This right has been advocated by the Occupational Hazards Task Group of the National Heart, Lung and Blood Institute (NHLBI): "Job transfer without economic penalty should be possible if necessary to protect the health of individual workers."

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EXHIBIT 92C

Statement of U.S. Department of Agriculture

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Our review of OSHA's inflationary impact statement reveals a very thorough and detailed analysis of the impact of the proposed cotton dust standards on the American cotton industry. The cost estimates in particular are quite detailed and confirm our belief that they are of such a magnitude that many textile mills either would not be able to make the additional investment, which would imply a drop in cotton use, or if they did make the investment, prices of cotton textiles would rise sharply. Either way, both cotton producers and consumers lose.

In fact, we believe that the inflationary impact analysis conducted by the Research Triangle Institute substantially underestimates the price impact on cotton consumption of implementing the proposed new regulations. The erroneous use of elasticities designed only for short-run use is primarily responsible. For example, the analysis was based in part on elasticities from our study, "U.S. Textile Fiber Demand-Price Elasticities in Major End-use Markets". These elasticities are very small and are useful only in the short run, i.e., a year or less. Over the longer run, price effects are cumulative and thus the impact is much greater. As pointed out in our study,—"these observations support the hypothesis that cotton demand is inelastic in the short run, particularly when cotton prices are declining. In the long run, however, demand would be expected to be less inelastic and may even be elastic with respect to price."—This means of course that a 10 percent increase in cotton prices, for example, may result in only about a 3 percent decline in cotton consumption in the short run, but may result in well over a 10 percent decline in consumption in the long run. Consequently, based on the increased costs of implementing the proposed cotton dust standards and their impact on

cotton prices, we believe that consumption will fall much sharper than envisioned in the inflationary impact statement. Thus, the economic impact on the cotton industry will be much more severe.

In contrast to the detailed cost estimates, the inflationary impact statement does not place a value on the benefits derived from adopting the proposed standards. We believe that such a cost-benefit analysis would reveal that the costs far outweigh the benefits. This is not to say that the health of textile workers is not important. But we do question the relatively small number of employees affected in relation to the tremendous costs associated with the adoption and implementation of the proposed standards.

In summary, we urge OSHA to adopt a cotton dust standard which is both technologically and economically feasible, for we believe that the future of the American cotton textile industry is at stake. The adoption of too stringent a standard will seriously disrupt the U.S. cotton industry, thereby undermining the livelihoods of many thousands of people who depend directly or indirectly on the production, marketing, and sales of raw cotton and cotton products.

EXHIBIT 101

Statement of John S. Barr, III

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I am quite aware of the fact that formulas can be constructed for calculating price elasticities of demand—formulas which theoretically, would enable one to compute the loss in volume that a 36¢ per pound increase in the price of cotton fabric would effect. But I also know that the limited published work on price and cross price elasticities in textile fibers has been very largely a reflection of its authors' subjective opinions and all of it relates to *short term* responses.

The real damage from a non-competitive cotton fiber or cotton product price accrues over the long term following management decisions which often involve the purchase and installation of equipment oriented toward alternate fibers. There are *no* reliable measures of *long term* price demand elasticities for cotton and other fibers.

Accordingly, the National Cotton Council will not attempt to project the absolute loss which cotton would suffer as a result of dust control costs. We do take exception to Research Triangle Institute's projection that the costs associated with the proposed dust standard would result in only a 310,000 bale total loss. The use of short term coefficients of elasticity in computing price-related losses for cotton renders their results totally invalid.

Moreover, Research Triangle Institute completely ignored the potential effect of higher costs and prices on U.S. *exports* of raw cotton. Inasmuch as 38 percent of U.S. cotton is sold abroad, we regard this as a rather significant oversight. Another curious oversight was RTI's failure to evaluate the effect of substantially higher yarn and fabric prices on the U.S. balance of cotton textile trade.

Seemingly, each of these points merit further thought for a better appreciation of the magnitude of cotton's

loss potential associated with the cost of this proposed standard.

First, the role of consumer demand: we have already noted the fallacy of using short term measures of elasticity to compute cotton's price-related loss potential and the absence of any long term coefficients. But, more and more, the morass of regulation which requires tremendous non-productive capital expenditures is preempting the consumer's influence on product availability.

Cotton's textile mill customers, for instance, are faced with a noise standard that is estimated to require billions of dollars in capital outlay, a dust standard requiring billions more, plus water and air pollution controls and flammability standards which will require an undetermined amount of capital. Where is this money coming from? Certainly not from internally generated cash flows. The annual expenditure required for the dust standard alone is nearly eight times the industry's profits from cotton textile sales. What textile mill owner or board of directors will assume these massive debt risks, on the *chance* that enough price increase can be passed on through the channel to cover costs and provide a meager return? And if such speculative principals can be found, what lending institution is willing to assume the risk.

Can there be any doubt that the textile industry would seize on every opportunity to substitute other fibers? Would they have any choice? By the time an engineered exposure limit of 0.2 mg/m^3 was required, would there be more than a token domestic market for cotton?

And, now what about the standard's potential effect on cotton's export market. We have shown that the cost of the dust standard in ginning, warehousing, merchandising and crushing would add 4 cents a pound to the price of cotton. In the last five years 38% of our cotton

marketings have gone into export channels. Since the foreign world consumes considerably more cotton than it produces, foreigners look to the U.S. for the remainder of their needs and the U.S. has been the world's leading cotton exporter. The price at which we export our cotton is the focal point for prices of foreign growths, making us the price leader for the cotton world.

Dust control costs will have to be reflected in U.S. cotton prices and these prices will in turn, result in higher cotton prices around the world. What effect will this have on U.S. cotton exports?

U.S. cotton's competition in the export market comes from two broad sectors—foreign cotton and man-made fibers. The higher prices resulting from the dust standard in the U.S. means a higher profit margin for foreign cotton growers, since these growers have no correspondingly higher costs. This tends to draw acreage in foreign countries away from food production into cotton production and narrows the deficit between foreign consumption and foreign production of cotton. This, in turn means smaller U.S. cotton exports, smaller foreign exchange earnings for our nation to help pay for foreign oil and other import requirements, and smaller markets for U.S. cotton growers. To put this into perspective, it might be helpful to observe that a 10% increase in foreign cotton production is equivalent to *all* of U.S. production for the export market.

Higher cotton prices worldwide also make cotton less competitive with man-made fibers and cause market losses to these fibers. This, too, narrows the gap between foreign cotton consumption and production, reducing U.S. exports even more.

Only when the U.S. is forced essentially out of the cotton export market will foreign cotton prices break away from U.S. prices and find a separate equilibrium.

OSHA's proposed dust standard would also have very serious implications for the U.S. trade balance in cotton textiles and textile products. In 1975 the U.S. trade deficit in cotton textiles approximated 300,000 bales. In 1976 the deficit widened to more than 600,000 bales, largely the result of a price disadvantage for U.S. cotton textiles. Imported cotton textiles accounted for 20 percent of domestic cotton consumption in 1976.

We find RTI's conclusion that the proposed standard would have no effect on foreign trade in cotton textiles difficult to reconcile with their observation that "large changes in the relative prices of domestic and foreign textile and apparel products do have an impact upon the domestic textile industry." RTI's study indicated that cotton fabric and yarn prices would have to increase nearly 18 percent to pay for the standard. Undoubtedly, they view this change as too small to make any difference in the ability of U.S. cotton textiles to compete in world markets. Yet, they observe that "international monetary changes since August 1971 have had a significant effect upon foreign trade of U.S. textile products." RTI failed to note that these monetary changes were equivalent to a 7.5 to 8.5 percent change in the price of U.S. cotton textiles—less than half the price increase which they estimate would be required to pay for the dust standard.

If U.S. cotton textiles are forced to take on a further 36¢ pound disadvantage, we will be hard pressed, indeed, to sell our cotton fabrics abroad and we might well be at the mercy of U.S. trade negotiators to retain, through quota arrangements, some portion of the domestic market for U.S. mills.

With respect to the proposed standard's cost, I want to underline what others have said about the interdependence of all sectors of the cotton industry. If OSHA's proposed dust standard is beyond the financial capability of one sector, it is beyond the capability of all, for no segment is dispensable. * * *

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EXHIBIT 111

Comments of the Council on Wage and Price Stability

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* * * The proposed standard fails to consider the differences in health impact signaled by the different types of grades of byssinosis. And the proposed standard fails to consider the effect on byssinosis prevalence of the current standard, which has been in effect only a short time and even now has not achieved full compliance. Many of the benefits of the proposed standard might actually be achieved by the present standard if the present standard were more vigorously enforced.[1]

The Role of Cost-Effectiveness Analysis

Although the Council on Wage and Price Stability Act, the two Executive Orders, and the OMB instructions quoted above all seek to promote cost-effectiveness in governmental decisionmaking, the Occupational Health and Safety Act does not directly mention cost-effectiveness as a factor to be considered in setting standards. However, section 6(b)(5) of the Act does require the Secretary of Labor to give due regard to the question of "feasibility."[2] As OSHA has stated in the *Federal Register*, "while the precise meaning of this term is not clear from the Act or the legislative history, it has generally been construed in a standard-setting context [to] include both technological and economic considerations" (41 *FR* 46748).

It is the Council's position that the goals and intent of the two Acts are consistent. In fact, we believe they are complementary because only the proper use of cost-

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[1] However, we are not arguing that the present standard be retained; rather the conditions used to support the current standard should not be used to again support a new standard before the impact of an enforced current standard is carefully considered.

[2] Public Law 91-596.

effectiveness analysis can "assur[e], to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life." [1] As long as OSHA places some limit to the costs an industry can bear before its existence is threatened and OSHA stops at that limit (or some earlier one), then it is a recognized scientific principle that more employees can be protected by a standard based on cost-effectiveness principles than one not based on cost-effectiveness grounds.[2]

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The major defect of the cotton dust economic impact analysis is that cost-effectiveness analysis by stage of processing or for the individual provisions of the standard has not been performed. The brief two page analysis that was performed (in the 543 page, two volume report) provides the decision maker with little insight since it only compares three alternative dust levels for one segment of the industry. Moreover, the analysis is replete with theoretical errors and inconsistencies.[1] If the decision maker had an idea of what costs he was willing to impose upon industry for the benefits produced, this type of analysis, properly performed, would help determine what dust level should be mandated for this segment of the industry. It should also be noted that the OSHA analysis is an implicit use of cost-benefit analysis. However, the point we emphasize is that once the feasible level of cost has been determined by OSHA, the use of

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[1] Section 6(b)(5) of OSH Act of 1970 (Public Law 91-596).

[2] For a recent careful application of cost-effectiveness analysis to the health sector see John Bunker, Benjamin Barnes and Frederick Mosteller, *Cost, Risks, and Benefits of Surgery* (New York: Oxford University Press, 1977).

[1] *Inflationary Impact Statement*, p. V-43, 44.

the methods outlined below would produce more protection for employees than the proposed OSHA procedures.

Costs of the Standard

The IIS estimates that the total annual cost of complying with the proposed 0.2 mg/m³ respirable cotton dust standard would be $694.9 million including an annualized capital charge of $433.6 million for capital costs of about $2.7 billion.[2] Estimates of annual costs of $82.5 million for a 0.5 mg/m³ respirable dust standard and $1,737.4 million for the 0.1 mg/m³ standard recommended by the Amalgamated Clothing and Textile Workers Union[1] are also presented. The Council is not able to judge the reasonableness of these estimates since it lacks the necessary technological and engineering expertise. However, we note that the estimates have been criticized as being both too high and too low. We have reviewed both sets of criticisms and find ourselves in sympathy with both.

The American Textile Manufacturers Institute criticized the IIS estimate for not including the cost of meeting the present standard and for using the old Internal Revenue Service depreciable life period for textile machinery of fourteen years to annualize capital costs while the new standard is eleven years. These modifications increase the annual cost estimate for the 0.2 mg/m³ standard to $823.7.[2] If OSHA is trying to estimate the full impact of tightening and enforcing a new standard on the financial viability of an industry it is correct to include the costs of meeting the current standard. It is

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[2] *Inflation Impact Statement*, p. I-25.

[1] See "Statement of L. K. Fitzgerald for American Textile Manufacturers Institute, Inc. Before the OSHA Cotton Dust Hearing", this docket.

[2] *Ibid.*, p. 6. The estimate refers only to the cotton textile industry and does not include cotton waste processing.

not correct if one is estimating the incremental costs and benefits of a proposed regulation. However, the IIS estimates total, not incremental, benefits,[3] and therefore counting only incremental costs is not correct. Ideally, both total and incremental costs and benefits should be computed so that the impacts of both the present and the proposed standards can be examined.

The second criticism on the length of the depreciable asset period holds only if the depreciation period reflects the economic life of the asset. If the economic life of textile machinery has not changed, then the new shorter depreciation periods actually indicate that the textile industry will have an easier time in meeting the new standards than the IIS estimated because of the greater cash flow. Since we have no estimates as to the actual economic life of the standard-induced equipment, a range of cost estimates should be presented.

While critics who argue that the IIS cost estimates are too high present a more appealing theoretical case, they do not present alternative numerical estimates. The Amalgamated Clothing and Textile Workers Union argued that the most serious deficiency in the IIS is the assumption of no technological change in the cost calculations.[1] As Nicholas Ashford puts it: "Decision makers who do not take proper account of the process of innovation are likely to overestimate the long-run costs of preventing occupational injury and disease."[2] The role of

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[3] For example see footnote d, table 1 below which has been reproduced from the *IIS*, table V-20, p. V-44.

[1] "Statement of the Amalgamated Clothing and Textile Workers Union, AFL-CIO" (April 5, 1977), this docket, Volume I, p. 20.

[2] Nicholas A. Ashford, *Crisis in the Workplace*, Cambridge, Mass.: the MIT Press, 1976, p. 338. The examples of vinyl chloride, asbestos, and now fluorocarbons appear to illustrate the principle that innovation reduces the *ex post* costs to compliance in comparison to the estimates.

innovation in reducing the hazards of byssinosis may be especially important for the proposed standard because of the relatively long proposed compliance period of seven years which should enhance the possibilities of innovation. Also to the extent that the final standard is a performance standard, the possibility that innovation will reduce compliance costs is increased.

Although it is impossible to estimate with much confidence the decline in the real costs of meeting the standard that technological change might produce, the ISS's assumption of no change probably overstates costs. In fact, according to a study by McGraw-Hill, the rate of labor productivity growth between 1967 and 1975 for a gray fabric textile plant was about ten percent per year.[1] It is likely that predictions of technological change based on past trends and expert opinion would provide a better estimate of the cost of compliance than do estimates based on a zero rate of technological change.

Taking into account the various biases, we believe that the IIS overstates the costs of the standards because of the strong incentive to reduce costs through technological modifications. However, we emphasize that this conclusion is extremely sensitive to the design of the final standard. We will suggest certain improvements in the proposed standard that should enhance the possibilities that innovation and technical change will substantially reduce the social costs of the standard.

Benefits

The benefits of the proposed cotton dust standard have also been estimated in the IIS; our feeling is that they too probably have been overstated. The primary benefit of the cotton dust standard would be a reduction in the prevalence of byssinosis. Byssinosis is a specific respira-

[1] *Textile World*, May 1976.

tory disease, the symptoms of which are caused by the action of some unknown agent or agents in cotton dust on the respiratory passages. The symptoms (shortness of breath and chest tightness) may be temporary or permanent depending upon the length and level of exposure and the individual. The symptoms of byssinosis have been classified by R.S.F. Schilling into reversible grades, grade ½, 1, and 2, and permanent incapacity, grade 3 as follows:

(a) Grade ½-occasional chest tightness on the first day of the work week.

(b) Grade 1-chest tightness and/or breathlessness on Mondays only.

(c) Grade 2-chest tightness and or breathlessness on Mondays and other days.

(d) Grade 3-Grade 2 symptoms accompanied by evidence of permanent incapacity from diminished effort tolerance and/or reduced ventilatory capacity.[1]

The reduction in byssinosis prevalence appears to be the only significant benefit of a cotton dust standard. Although OSHA states that other respiratory diseases such as chronic bronchitis may also be caused by cotton dust,[2] Dr. Arend Bouhuys, director of the Yale University Lung Research Center, has pointed out that the continuing discussion concerning the co-existence of chronic bronchitis and of byssinosis is one of semantics.[3] "There is little or no reason to describe cotton textile workers . . .

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[1] 41 *Federal Register* 56580. Also note that according to the IIS, there is no evidence of excess mortality among American textile workers. (*IIS*, p. III-6)

[2] *Ibid.*, p. 56501.

[3] Letter from Arend Bouhuys M.D. to Walter Gawlak, February 22, 1977, with comments on proposed Cotton Dust Standard.

as having some separate disease entity labeled chronic bronchitis." [1]

The IIS also mentions several other possible benefits such as cleaner workrooms, reduced workmen's compensation costs, discovering other respiratory diseases from the medical surveillance program, medical records useful for scientific studies and "some small improvement in product cleanliness and quality." [2] With respect to increased cleanliness, since the proposed standard would apply to invisible dust while the current standard applies to all dust, it is possible that the shift to the control of invisible dust might actually increase visible dust and therefore have the opposite effect. In any case we doubt that the amount of visible cotton dust in workrooms has the undesirable effect on worker morale hypothesized in the IIS.

Counting a reduction in workmen's compensation premiums as a social benefit is a common mistake in this type of analysis. The reason that these costs should not be counted as additional benefits to the standard is because the reduction in payments by firms is matched by a reduction in payments received by workers.[3] In other words, workmen's compensation payments are simply transfers from one group to another while the real benefit is the decline in byssinosis prevalence.

The benefits from medical surveillance and record keeping are real but probably small. It should also be noted that they are not attributable to the engineering and administrative controls analyzed in the IIS.

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[1] *Ibid.*

[2] *IIS*, p. III-19-20.

[3] This is true except for the cost savings of administering a smaller workmen's compensation program. However, the administrative costs that OSHA will incur in establishing and enforcing a cotton dust standard have not been counted, either.

The IIS uses estimates of byssinosis prevalence by cotton dust exposure level to calculate the number of byssinosis cases that would be prevented by the three cotton dust levels, 0.5, 0.2, and 0.1 mg/m^3 respirable, for which it also calculated cost data. The major flaw in the analysis is that incremental benefits are counted from current conditions which do not, in general, conform to the present standards. On the other hand costs were calculated from an assumed compliance with the present standard to compliance with the new standard. Thus, costs and benefits are not measured symmetrically.

A second problem with the benefit estimate is that all grades of byssinosis are lumped together in the IIS. Thus symptoms such as occasional chest tightness on Mondays are equally weighted with "permanent incapacity" and combined into one simple index. Although it is most difficult, as the IIS points out, to assign dollar values to health benefits, a system that simply sums all degrees of health problems from the serious to the inconsequential omits important information and may be misleading. Furthermore, if eliminating "material impairment" and not occasional discomfort is OSHA's main concern, then standard development should focus on the irreversible harmful health effects. As Dr. Russell Harley has testified, "Grade ½ 'byssinosis' is a nebulous entity, probably useful in epidemiologic work, but hardly acceptable as a 'disease.'" [1]

Finally, the underlying data used in the IIS to estimate benefits are subject to major criticisms and are on the high side compared to other estimates that have been made. The IIS's basic data for the benefit estimates are based on the study by James Merchant *et al.* pub-

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[1] Statement of Russell H. Harley, M.D., before OSHA on the Cotton Dust Standard, this docket, p. 2.

lished in *Journal of Occupational Medicine.*[2] However, Dr. Moon W. Suh, a statistician for Burlington Industries, makes a strong case that there are errors of statistical design and analysis in the study that create an upward bias in the estimated dose-response relationship between cotton dust and byssinosis.[3] He has testified that the sampling procedure was not random but biased toward the worst plants, that the probit analysis used in the study was not appropriate, that geometric means and medians were used when arithmetic means would have been appropriate, that certain sample points were incorrectly dropped from the analysis, and that the data were not randomly grouped.[4]

The results of the Merchant study also appear to be high compared to other studies listed in the National Institute for Occupational Safety and Health (NIOSH) criteria document.[5] For example, NIOSH states:

> "To summarize, the prevalence of byssinosis, Grade ½ or greater, among carders has been found to be from 20-40% in the most recent British and American studies.[1]

However, the IIS uses a byssinosis prevalence estimate for carding of 50 percent (based on Merchant's data) in estimated benefit levels.[2]

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[2] James Merchant *et al*, "Dose Response Studies in Cotton Textile Workers," *Journal of Occupational Medicine*, March 1973).

[3] "Statement of Moon W. Suh, before OSHA on the Cotton Dust Standard," this docket.

[4] *Ibid.*

[5] *Criteria for a Recommended Standard Occupational Exposure to Cotton Dust* NIOSH, 1974.

[1] *Ibid.*, p. 50. The range for the United States was 20 to 29%. (See table XII-6, p. 145, *Ibid.*)

[2] See *IIS* p. III-11.

The IIS further overestimates benefits because it assumes that the risk of byssinosis for new workers is equal to the byssinosis prevalence estimate developed by Merchant *et al* for all employees. Merchant's study estimates the current [1970-71] prevalence of byssinosis for workers who in the past have likely been exposed to higher levels of cotton dust than they are now exposed to. As Dr. Bouhuys points out, byssinosis has been recognized as an important health hazard to U.S. cotton textile workers only since 1967.[3] Additionally, cotton dust was not regulated until 1968, under the Walsh-Healy Act which applied just to government contractors, and until 1971 as one of the consensus standards under 6(a) of the OSH Act. As the IIS points out, this regulation has not as yet been fully achieved.[4] Thus, presumably over time average dust levels have been declining and will continue to decline at least until the present standard is met. Using historical byssinosis prevalence rates will thus overstate the benefits of a new standard.

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Again it should be noted that both the benefit data and cost data examined here refer only to the impact of the dust level control program. It may be that the benefits of the medical surveillance program or the respirator program would be greater than the benefits provided by the dust control program. * * *

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* * * These two provisions might provide more cost-effective solutions to the byssinosis problem. The cost-effectiveness of each provision should be examined independently and in concert with the other provisions in order to ensure the most protection for the least cost. This the IIS does not attempt.

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[3] See "Statement by Arend Bouhuys," *Op. Cit.* p. 6.

[4] *IIS*, p. V-8.

An Alternative Proposal

Lack of information, both on the economic impact and the health benefits of alternative standards makes the setting of a reasonable standard an exceedingly complicated process.

In addition to the problems of estimating the costs and benefits that we have discussed, perhaps the major shortcoming of the proposed standard is that the substance to be regulated, respirable dust, is only imperfectly related to the performance we desire—improved employee health. As pointed out earlier OSHA does not know what the actual substance or substances are that cause the symptoms of byssinosis.[1] The toxicity of the regulated substance varies depending upon stage of process, type of cotton, blend of synthetics, ambient dust levels, and methods of picking and cleaning, but not directly with "respirable dust levels."

Several investigators have suggested that the standard should provide a feedback mechanism between the results of the medical surveillance program and the effectiveness of engineering controls.[2] The standard could simply specify the required results of a medical surveillance system. Such a system would be workable because the early stages of byssinosis are detectable and reversible. * * *

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Conclusion

The Council on Wage and Price Stability has carefully examined the *Inflation Impact Statement* and the

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[1] For example, Dr. Bouhuys believes that there might be several active agents, perhaps with different agents responsible for different grades of byssinosis. See "Statement of Dr. Bouhuys," *Op. Cit.*, p. 3.

[2] For example see *Ibid.*, p. 8 and "Statement of Amalgamatical Clothing and Textile Workers Union," Vol. II, *Op. Cit.*, p. 16.

record pertaining to costs and benefits in this hearing. We believe that the proposed standard could impose excessive costs upon the cotton processing industry unless the standard is carefully formulated to take into account cost-effectiveness considerations and the potential for including positive cost-reducing innovations.

We have criticized the IIS for not carefully taking into account the full implications of the proposed action or considering alternative regulatory approaches that have the potential to both reduce costs and increase benefits, perhaps at the cost to OSHA of a slightly more complicated and expensive enforcement effort. We urge OSHA to consider the full range of alternatives and to develop the information on costs and benefits necessary for rational and effective standards development.

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EXHIBIT 113

Statement of Sidney M. Wolfe, M.D., and Peter Greene

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Furthermore, studies of employed cotton workers at a frozen moment in time tend to overstate the number of "reversible," and understate the number of "chronic," brown lung cases caused by a given dust level. This is because workers retire and drop out of the study population when their "reversible" symptoms become chronic. Thus many workers who are listed as having "reversible" or low grade byssinosis in the factory studies will actually go on to develop chronic byssinosis.

A new community-based study by Bouhuys *et al.*, described by Bouhuys in his testimony here, confirms the previous underestimation of chronic byssinosis.

The point is that OSHA cannot disregard cases which are listed as "reversible" in the "one-shot" factory studies, without seriously underestimating the dose-response relationship for chronic byssinosis and setting the standard too leniently (too high).

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EXHIBIT 124

Bouhuys, *et al.*, "Epidemiology of Chronic Lung Disease in a Cotton Mill Community"

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Most surveys in industry have shown an excess of chronic respiratory symptoms, as well as loss of lung function, among active workers at risk[29, 34]. However, the total population of textile workers at risk of chronic disease also includes retired workers. Active workers form a group biased in favor of healthy individuals. Retired workers, in contrast, include those who left the mills because of disabling lung disease, and thus this group is biased in favor of diseased persons. We had previously identified several cases of disabling byssinosis among retired workers who lived in mill communities[9]. To describe the prevalence of chronic lung disease adequately, we therefore decided on a community-based study which would include retired as well as active workers.

We are confident that our results in members of the original cohort of carders and weavers (Table 1; Group A in Table 3) provide a reasonably accurate picture of the respiratory health of active and retired cotton textile workers who continue to live in the community surrounding the mills. Of those whom we identified and traced, 95% participated in the study. The results obtained in this cohort were similar to those in the additional group of men and women studied (Group B in Table 3). We have concluded that the total study group, too, is representative for active and former cotton textile workers in that community.

However, many persons on the employment lists could not be traced; probably most of these left the mills and moved away. They may have moved to find jobs elsewhere, or they may have moved to a better climate. Since we studied persons 45 years of age and older, the first

motive is probably infrequent. Also, we were more likely to trace active rather than retired workers. The prematurely retired men whom we studied had lower function values and more symptoms than the men who were still active in the mills. Therefore, those we could not trace may also be a group biased in favor of diseased subjects. If so, our data underestimate the true prevalence of chronic disease among the total population at risk. In a similar study of hemp workers in Spain[8], disabling lung disease among men was more prevalent than it was in the present study.[14]. We know that hemp dust is more toxic than cotton dust[33], but it is also possible that we were better able to trace older disabled men in Spain, since few of them had moved away.

We are confident that the differences in lung function between textile workers and controls reflect excess loss of lung function among the textile workers. All methods were standardized and identical for textile workers and controls. Throughout all studies, our MEFV curve recordings were calibrated every two hours with a device that accurately reproduces a standard MEFV curve[12]. In addition, the computer methods are inherently more accurate than methods which rely on analog readouts and graphical recordings. Flow measurements with the computer system are accurate to about 0.3%; the system reproduces the $FEV_{1.0}$ of the calibration device to within 0.6%[12]. Hence, we minimized technical sources of error.

The data on respiratory symptoms and lung function indicate an excess of chronic lung disease among the cotton textile workers (Table 4, 7, 8). It is almost certain that the difference in lung function and in symptom prevalence between textile workers and controls is caused by dust exposure of the workers in the mills. For the symptoms, the weighted least squares analysis indicates that work in mills is the prime variable—the only one for dyspnea grade 2+—while smoking is a contributing

factor for cough, phlegm and wheezing. For lung function, the differences between workers in risk jobs and in other jobs (Table 8) suggest that the lung function decrements are caused by exposure to dust. For both symptoms and lung function loss, the differences between textile workers and controls persist when sex, age and smoking habits are taken into account. Other factors (e.g., urban air pollution, indoor air pollution, altitude) have been considered and may be excluded. Within our control populations there are no systematic differences in lung function that might be related to urban air pollution outdoors[31]. Indoor air pollution has so far not been linked to excess airway obstruction, e.g., among nonsmokers who live in homes with smokers[30]. All subjects lived at similar altitudes, near sea level.

It is important that the small group of textile workers in other jobs, not exposed to dust, was similar to the control subjects in other communities. The workers at risk and those not at risk were studied on the same days and with the same methods, and lived in the same community under similar conditions. Thus, we can exclude the possibility that the textile worker population as a whole differed, for some unknown reason, from the control populations. The differences in lung function are related to specific jobs in the mills, not to some unknown characteristic such as social class of textile workers as a group.

We found an excess of chronic lung disease not only among carders and spinners—groups long known to be at risk of byssinosis—but also among yarn preparers and weavers. It has frequently been stated that byssinosis is absent or uncommon among weavers. However, a detailed study of one mill showed that most weavers in a factory which produced heavy cloth from unsized yarns had byssinosis[5], and in a more recent study[24], the average prevalence of acute byssinosis symptoms among 431

workers in slashing or weaving was 13.1% (36.5% in a subgroup exposed to high dust levels).

The excess of chronic disease among textile workers might be overestimated if the control populations were biased in favor of healthy persons. However, we have evidence that our control subjects provide an accurate picture of the respiratory health of the total populations in their communities[26]. The prevalence of key respiratory symptoms in our control subjects is roughly similar to that in other populations not exposed to major risks of occupational lung disease[1, 28]. Furthermore, the negative lung function residuals among most subgroups of control subjects (Table 7) reflect the inclusion of diseased persons and smokers.

Chronic lung disease among cotton textile workers is obviously an important public health problem. Among those who retired before the age of 65, 18% gave chest symptoms as the prime reason. Of all textile workers, 5.0% of those aged 45-64 years, and 17.4% of those 65 years and older, had $FEV_{1.0}$ values of 1.20 liter or less, i.e., values consistent with considerable disability in most instances. On the basis of these data, and of employment figures in the U.S. cotton textile industry, we have estimated that about 35,000 men and women in the U.S. suffer from disabling lung function loss as a result of their work in cotton textile mills[14]. This figure may be too low, since we may underestimate the prevalence of chronic lung disease among the total population of workers at risk (see above).

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EXHIBIT 143 APPENDIX F

The economic structure of the textile industry

By JORDAN P. YALE *

FOR MANY YEARS, particularly during the 1960s and early part of the 1970s, the business cycle lost its serious impact on the economic life of not only the nation, but also on the textile and apparel industries. This change came about not because the effect of the business cycle disappeared from our business dealings, but because other influences became more dominant. The most significant of these was the element of growth. During this period, growth dominated the economic climate, having moderating effects on cycle fluctuations. The business cycle was ever present; however, it was not felt or manifested in plant closings or massive worker layoffs.

In terms of the national economy, there were two primary factors that contributed to the softening effects of the cycle: 1) The existence of regulating legislation (minimum wages, unemployment benefits, rigid monitoring of banks and stock market), and 2) Improved management techniques (extensive use of short and long range planning and inventory control). In addition, the textile industry had some other important considerations in its favor namely, the innovative breakthoughs introduced by the synthetic fiber industry (by means of which textile markets expanded) and the growth in the share of synthetic fiber consumption. The growth in the consumption of synthetic fibers with their relatively stable prices reduced the need for speculation by textile mill management. Also, during this period there was

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* Dr. Jordan P. Yale is president of Statistion Corp., P.O. Box 246, East Norwich, N.Y. 11732 (516 922 0382), publishers of the quarterly journal Textile Business Outlook and of the recently completed multi-client study Polyester Staple Growth. 1932-1935. He is also a textile economics consultant.

a significant increase in the consumer's propensity to spend on textile articles. This increase in expenditures was the result of the changes in the demographic composition of the population (faster growth of the younger group, greater personal income, changing life styles and other factors).

In a previous article, "The Textile Business Cycle," which appeared in the July 1975, MODERN TEXTILES, the

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Textiles, one of the nation's oldest industries, is currently undergoing a renaissance that could transform it into one of the leading U.S. industrial sectors. A noted consultant and forecaster tells why.

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behavior of the textile cycle was described. Since then, the Federal Reserve Board, the raw data issuing agency, has made major revisions of the current and historical data. As a result, it is one of the aims of this article to redefine the textile cycle, to also describe the apparel production cycle and to compare them both with the national cycle as defined by the F.R.B.'s Total Industrial Production Index. These comparisons have revealed for the first time the importance of the cyclical timing of both the textile and apparel industries: *They both lead the national economy in predicting cyclical changes, and therefore both can be classified within the group of leading indicators of national activity.* Prior to the period under study, the textile cycle was lagging the national cycle. Also, a comparison will be made between the U.S. textile cycle and the textile cycles of a number of countries around the world in order to determine the existence of any relationship in their timing.

Further, it is the aim of this article to define the primary reason which has contributed to the growth of

the textile industry. For the period starting in 1960, and up to the present, the chief factor contributing to this growth has been the "consumer" who has spent large sums on textiles, significantly more than accounted by management. As a result of the large expenditures, total per capita fiber consumption has been increasing.

In recent years, the classical or economic description of the textile industry as a "sick" industry does not hold water anymore. This industry is dynamic and it is one of the few industries outside the space/industrial complex that has experienced a relatively high degree of technological inroads.

In this article, a description will also be made of an economic model of the textile industry, identifying the significant input-output relationships between the business elements (petrochemical, fiber producers, apparel manufacturing, etc.) that have a bearing on the well-being of this industry, and in turn they are affected by it.

Finally, in this article a presentation will be made of the latest short term economic forecasts relating to the industry.

Cyclical Changes

Business cycles are defined as fluctuations in activity of duration longer than one year. The length of the cycle can be measured as the distance between two consecutive low (or tough) points, or two high (or peak) points. Measuring the length of a cycle between two tough points provides a greater degree of reliability in such lengths.

Even though our discussion in this section will center on the economic behavior of the textile industry as measured by the F.R.B. Textile Mill Prod-time, identifies the sum total of these textile expenditures. They are significantly larger than are commonly thought to be.

a) *"Consumer" Textile Expenditures—A Hidden Colossus*: Earlier it was demonstrated that most of the socio-economic variables are positively correlated with the consumption of apparel, homefurnishings and during the last 10 years with industrial end use applications. Therefore, as these variables grow, the textile industry also grows. As shown earlier in Figure 1, the textile industry has been experiencing growth for many years. In contrast, it is often heard that over the years the consumer is spending a declining share of his expenditures on textiles.

This article takes an issue with such an assumption. It is believed, and will be demonstrated for the year 1974, that the share of consumer expenditures on textiles is far greater than what it normally is assumed to be. There are also indications that this share is increasing.

There is a misunderstanding about the nature of consumer expenditures directed to textiles. This confusion is related to the statistical record normally released by the Department of Commerce. The reported purchases deal only with direct consumer expenditures on *apparel* textiles as well as some of the other major types of expenditures. Major textile purchases, such as carpeting, etc. should be classified as textile expenditures but are currently classified under homefurnishings along with appliances and furniture. There is a significant quantity of other textile material such as upholstery fabrics, threads, fiberfill, linings, tire cord fabric and others that are an integral part of another fabrication and not included under textile expenditures. For instance, tire cord represents a better than 600 million pound fiber market but its retail value is included within other tire components (rubber, metal and others) and, of course, sold as tires.

Another large market, draperies and upholstery (including those used in vehicles) is largely disregarded in

the calculation of direct textile consumer expenditures. This market (primarily the upholstery material) is included with the consumer expenditures on furniture. There are many other end use applications which "hide" their textile contents and therefore contribute to the understatement of direct textile consumer expenditures. End uses, such as reinforced plastics (approximately 500 million pounds), electrical applications (41 million pounds), and many others, are not considered. It is apparent, therefore, that a significant portion of textile materials is not counted as textiles at the retail level, but is included as part of the retail value of other types of consumer expenditures. It is difficult to estimate the exact amount of consumer expenditures on *all* the textile materials, and, particularly for textiles, that are used in industrial applications. It is safe, however, to assume that the industrial portion of use of all textile material is small.

Based on a number of assumptions, an estimate was made of the total "consumer" expenditures on textiles, directly and indirectly. The word *consumer* in the context of the present analysis not only includes the direct purchaser of textiles at the department or other retail stores, but also the processor who buys textiles for further use (such as the furniture, automobile manufactuers, along with the methodology used in arriving at it, are shown in Table VI. The conversion factors in the table have been derived very carefully, but there could be some difference of opinion as to their magnitude.

The main conclusion reached in Table VI is that "consumer" expenditures on all textile items (direct and indirect) as a percent of total expenditures, have been seriously underestimated. According to the U.S. Department of Commerce, the consumer spent $65.2 billion on clothing and shoes in 1974, a share of 6.62% of his disposable income. (Please note that part of this share

belongs to shoes.) According to the estimates shown in Table VI, the "consumer" in fact had spent a total of $129. billion on all types of textile goods in the same year. These expenditures are also "pure textile" and do not include expenditures on shoes or other items. The ratio of the calculated textile expenditures to total disposable income in 13.11%, approximately twice the amount calculated from the USDC data. The textile industry is capturing a far more significant share of the consumer expenditure dollar than is currently recognized.

The breakdown of the consumer's textile dollar at retail equivalent value according to the three major market areas is shown in Figure 3. Expenditures for apparel represent a 55% share, while expenditures on home furnishings 33% and expenditures on industrial end uses 12% of the total textile dollar.

The fact that total consumer expenditures on textile are far larger than recognized, with the possibility that they are increasing over the long term, is also supported by the trends in total per capita fiber consumption, shown in Table VII. Here, again, a different basis is used in measuring per capita consumption. This consumption is at the mill level and in addition to domestic shipments and imports of fibers, includes other natural fibers such as silk, linen, jute, sisal and others.

Finally, it also includes the consumption of waste fibers. Based on the calculated total fiber consumption, the per capita rate is 54.5, 43.9, 54.0 and 58.6 pounds for the years 1950, 1960, 1970 and 1974. Based on the traditional measurement of per capita fiber consumption, the rates are 44.7, 35.6, 46.1 and 51.6 pounds, respectively for the previously mentioned years. The total per capita fiber consumption is given, annually, for the period 1950-1974 in the graph in Table VII. Trends in per capita fiber consumption indicate that the lowest consumption was reached in 1958; since that time the per

capita rate has been increasing. It appears that trends in per capita fiber consumption are also subject to cyclical fluctuations. It is expected that growth trends experienced during the past few years will continue, and by 1985 the per capita rate is estimated to reach 80 pounds.

The Influx of Technology

If the degree of innovative effort can be measured by the dollars spent on research and development, the textile industry would then be classified as a "poor innovator". The textile mill products industry, however, has been the beneficiary of research and development efforts carried out by the fiber industry, the domestic, as well as foreign, machinery manufacturers, the dyeing and auxiliary chemical industries and a number of other industries.

During the past few years, there have been some major technological breakthroughs which were felt in the following areas:

1) A continuous manufacturing process flow, in contrast to an intermittent one.

2) Drastic reduction in the number of processing steps and in the number of equipment. Use of equipment with higher speeds.

3) Drastic reduction in manpower.

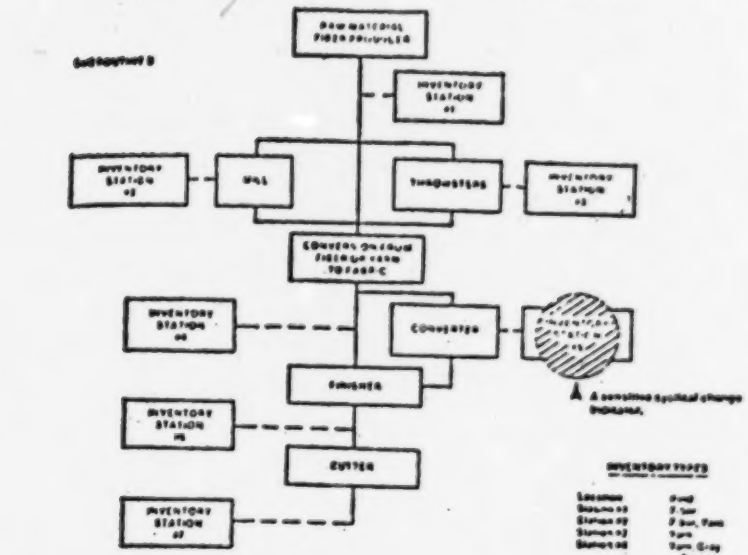
4) A gradual shift in the job content, from one requiring primarily manual skills to one requiring electromechanical skills.

As a result of these major changes, the textile industry is currently in the early stages of a long-term overhaul which will alter the industry from a labor intensive force to a capital intensive force. The direct beneficiaries of these changes will be both the worker, who with his increasing productivity and expanding skills

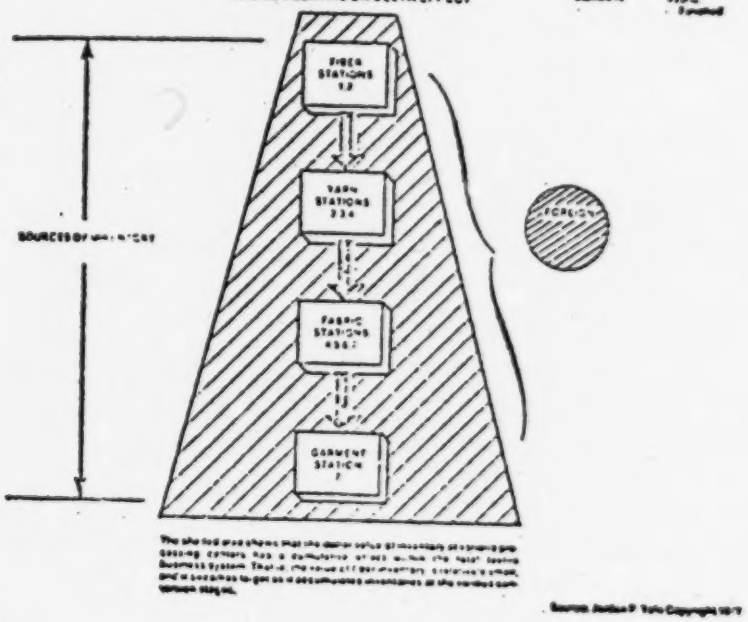
will receive considerably improved wages and benefits, and management, which will improve its overall profitability.

FIGURE 8

SCHEMATIC DIAGRAM OF SHIPMENTS AND INVENTORY ACCUMULATION



TEXTILE INVENTORY PIPELINE
THE CUMULATIVE OR DELTA EFFECT



The key to these changes is the adoption and use by the mills of technologies and equipment currently available in the market place. The major centers of new mill technologies will be discussed in the following section.

A) *Mill Processing Technologies*: The main objective of a mill processing system is the conversion of a mass of fibers into a yarn and fabric and is dependent upon fiber properties. One of the most critical properties in the conversion sequence is fiber growth. There are many conversion systems, and they seem to fall into three major groups, as shown in Figure 4—Part A, Part B and Part C. Part A describes the various processing systems that are used in the conversion of fiber into a yarn or directly into a fabrication. Part A is further subdivided into Systems, I, II and III and a general description of these systems follows.

1) *Conversion Systems*:

Part A: Conversion System I. Staple Fiber to Yarn: The traditional spinning system deals with the conversion of a loose form of fibers into a yarn. The staple fiber can be either naturally grown, synthetic or garnetted (recycled from old garments, yarn or fiber waste). Since cotton is naturally tangled and contains large amounts of foreign matter, the traditional cotton system subjects cotton fibers to a severe treatment. The same is true for the worsted and woolen systems. Due to the content of significant amounts of grease and other foreign matter, wool is first required to be scoured for the removal of grease, and then carded for opening up the fibers and rearranging them parallel to each other.

The advent of synthetic fibers produced a fiber with unique characteristics. The mass of fibers was clean, parallel and of uniform length. This new form of raw

material eliminated the need for excessive treatment and resulted in the development of new modified processing systems. These systems are the modified cotton system, the tow-to-top, Mackie and American systems.

Yarn Spinning Technology: After a thrust of technological innovation which took place many years ago, technological progress within the textile industry practically came to a standstill. During the past 25 years, there have throughs, such as improvements in long drafting, development of yarn texturizing, tufting and various non-woven processes, including needle punch. In the last five years, however, a number of important mechanical innovations have become a commercial reality. *These developments are expected to change the structure of the industry from labor intensive to capital intensive.* In one recent development, open end (OE) yarn spinning, the drafting apron is replaced by a rotor which results in a significant increase in yarn production. In another technological development concerning weaving, the introduction of shuttleless weaving looms which can be run at higher speeds than previously used looms has resulted in the reduction of production costs.

There is currently a considerable concentration of technological activity on the creation of new yarn spinning technologies. In addition to the OE spinning, there is also a newer development involving the Polish air vortex open end spinning system.

Part A. Conversion System II. Filament to Filament Yarn: This conversion procedure deals primarily with filament yarns (with the possible exception of core yarns where a yarn is formed by wrapping stable fibers around a filament core, or vice versa). The important development in this section is the growth of texturized yarns, primarily that of polyester filament, with their multivaried end use applications.

Part A: Conversion System III. Staple Fiber to Fabrication: The primary method of producing fabrications directly from the fibrous state is by means of the various processes shown in Figure 4. Non-woven fabrics are fibrous structures and the fibers are held together by means of mechanical friction or chemical bonds. Flocked fabrics are formed by bonding tufts of fibers on a fabric substrata. Batting structures are formed by inserting loose fibers between fabric enclosures. Needle punch fabrics are formed by means of a needling action.

Part B: Conversion System IV. Yarn to Fabric: This conversion system depicts the major processes followed in the utilization of yarn for the manufacture of different forms of fabrics. Knitting primarily utilizes filament yarns. For instance, in warp knitting, used primarily for women's undergarments, nylon and acetate filament are the predominant fibers. In well knitting, used principally for outerwear garments, the main fiber used is polyester textured filament. There is also a significant volume of acrylic used in sweaters and men's hosiery. The volume of polyester staple consumed within knitting is small. The tufted process is used primarily in the manufacture of carpets. Recent developments in fine gauge tufting could make this process available to producing upholstery fabrics.

Braided products are ropes and twine, while the Mali and lace processes are used on specialty fabrics.

Part C: Conversion System v. *Polymer to Fabrication:* In recent years there has been many attempts to manufacture various fabrications immediately after the extruded filament leaves the spinneret. For instance, polyester filament is converted into a spunbonded construction in this manner. Other processes deal with the transformation of polypropylene film into a tape yarn, and its use thereafter in carpet backing and ropes. In more recent

years, attempts have been made to produce end uses, such as carpets, by means of molding. In this process, the polymer is poured between two open strata and formed into two flat surfaces connected by means of rod-like threads. These threads are then sheared, leaving two separate tufted surfaces ready to be used as carpets.

Summary Comments: During the post World War II era, and more particularly since the 1960's, there have been significant breakthroughs in the availability of new yarns (tapes, films, etc.) and fabrics. New fabric formation processes, such as tufting, texturizing, non-woven processes, looms, automatic screen printing, transfer printing, computer assisted designs, new dyeing and finishing processes, have contributed toward: 1) Reduction in the processing length: 2) reduction in labor requirements; 3) increased productivity; and 4) introduction of automation.

The new technology introduces a radical change over the existing technology. For instance, OE spinning frames have radically different drafting zones than the conventional spinning frames. Spunbonded fabrics are radically different structures than the woven fabrics. Transfer printing is a radically different process than roller or screenprinting. This is also true for many other technologies. Most of the new technologies are so radically different than the existing technologies that it is possible to describe the textile industry as one of the few industries, outside of the space/industrial complex, that has experienced a relatively high degree of technological inroads.

Our discussion up to now has indicated that the textile industry has gone through a major transformation over the past few years. It has become a stable industry, combined with growth, a significant technological infusion and a very receptive "consumer", spending significant sums for the purchase of textiles.

There are two ways of looking at the textile industry, one is according to the definition used by the government. This offers a narrow point of view while serving statistical survey purposes. The government's view is short sighted and can even be called myopic from a business point of view. The other view in looking at the textile industry is as a conversion system, taking in raw materials at one end and creating textile consumer values at the other. This topic will be discussed in the following section.

The Statistikon Textile Economic Model

A) *Industry Organization* *: The ultimate objective of the sequence of manufacturing steps from the raw material to the final garment is the creation of a product that will appeal to the consumer and thus create a desire for the purchase of the garment. In this sequence of manufacturing steps, there are several management decisions to be made affecting the various products. These decisions influence the final success of the end use. A listing of such major decisions is as follows:

1) Decisions regarding the process of manufacture that would be suitable for the quality of materials, starting with the raw state to the finished garment.

2) Adjustments made in the various processing stages to accommodate the variability of materials.

3) Proper pricing decisions for the purchase of raw materials for immediate needs and protection against fluctuation of future prices.

4) Decisions regarding the flexibility of the equipment used. It is possible to build a manufacturing process that

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* Jordan P. Yale Innovation: The Controlling Factor in the Life Cycle of the Synthetic Fiber Industry. A Ph.D. dissertation, New York University.

would handle only a certain type of fiber, such as cotton, wool, worsted, synthetics, or any other single type of fiber. If the processing system is not made flexible to accommodate several types of fibers, management might be forced to use an obsolete processing method.

5) Decisions regarding production of future fabrics, as to the type of construction and style to be produced. This decision is very important for the apparel type of fabrics. It will prove very costly if a mill fails to make the proper market appraisal.

6) Decisions regarding the manufacture of a garment. A garment cutter must first decide what would appeal to the consumer before he starts producing it. There is usually a time lag of more than four months from the purchase of the fabric and the delivery of a garment.

The extent of influence of any of the above decisions is not limited to the immediate area that called for that decision. A decision for instance on any aspect of quality * * * * * * * * * have a broad effect on fabrics and garments made from it. Likewise, a decision based on the manufacture of a garment will have a feed-back effect on the fabric and eventually on its raw material components. If the garment sells successfully, then obviously fabric production and raw material consumption will increase. If the sale of a garments is not successful, the reverse will be true and fabricated fiber consumption will decline. As can be seen, then, a certain close inter-group relationship and dependence exists between all the factors of production, from the textile raw material supplier to the finished garment manufacturer. All the functional groups involved have a single common objective, the sale of textile goods to all types of consumers.

Since there is such a common purpose, whether recognized by the industry or not, a definition of what is meant

by the expression "textile industry" should include *all aspects of textile material conversion activities.* The current industry definition is weak: it creates an atmosphere of vagueness. Textile industry means textile mill products, and certainly these two terms are not the same. In the following section, the discussion will extend, clarify and amplify the problem of the definition of the term "textile industry".

B) *Weakness of Definition "Textile Industry":* There is not, as yet, a comprehensive definition of the textile industry. The definition given by the Office of Management and Budget describes technically only a segment of the overall textile industry. According to this definition, textile mill products and its implied synonymous term "textile industry" are described as follows:

> "This major group includes establishments engaged in performing any of the following operations. 1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine and cordage, 2) Manufacturing broadwoven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn. 3) dyeing and finishing fiber, yarn, fabric and knit apparel 4) coating, waterproofing, or otherwise treating fabrics, 5) the integrated manufacture of knit apparel and other finished articles from yarn, and to the manufacture of felt goods, lace goods, bonded-fiber fabrics, and miscellaneous textiles.

This Bureau of Budget definition is strictly oriented to manufacturing and serves the purpose of facilitating statistical surveys. It is production oriented, and only partially at that, and fails to cover the manufacturing or supplying of raw materials and the manufacture of clothing. What the industry needs, however, is a definition that parallels the industry objective—the objective of creating more textile sales. In other words, we need a *business definition* of the industry.

* * * * *

It is important for the textile industry leaders to recognize that the above actions have to be taken in the very near future since there already exists a market momentum favoring textile consumption.

The past development of textile economic matters has been favorable. With the last cycle, however, new national economic problems have emerged, i.e., inflation in conjunction with high unemployment. The near-term effect of both factors will be that there will be a moderating effect on economic growth. Our concern, then, will turn to the evaluation of the short term economic climate for the U.S. and eighteen foreign countries. The economic appraisal will deal with national economic parameters, as well as textile. The discussion on this topic follows.

Short Term International Economic Expectations

During the first quarter of 1975, the botton of the previous cycle was reached and since that time the national economy, textile and apparel industries have been experiencing an economic revival. The improvement in business conditions has not been smooth. Activity for all indicators expanded rapidly at first, but then seemed to falter. This faltering lasted until the last few months, where upon a new business revival, spirit took hold. The national economy did not run the risk of falling into a recession again. What happened is that the economy went through a correction period resulting from: 1) adjustments made due to strikes (primarily in the automobile and tire industries); 2) adjustments in the inventory levels, particularly unique to the textile industry; 3) adjustment in fashion trends, such as in the case of double knits; and 4) adjustments which were necessary due to the energy crisis.

It appears that the national economy has entered a phase of reduced growth, and as a result the effects of any business disclocations, such as inventory adjustments or

other types of changes will make a more pronounced effect on the economy.

Currently, the economy has resumed its growth. The negative psychological impact of the significant inflationary trends has lost ground in the consumer's, as well as the businessman's, mind Both have confidence in the economy, as well as the government. An indication of this confidence is reflected in current increases in consumer in-

TABLE IX: Resources Demand, Estimated
Petrochemicals and wood pulp (million pounds)

Type of fiber and material	1976	1977
Polyester		
DMT	2,748	3,125
PTA	759	868
Ethylene glycol	1,550	1,768
Nylon		
Cyclohexano	1,556	1,743
Duladiene	678	759
Acrylic		
Acrylonitrite [1]	1,025	1,146
Comonomer	91	102
Olefin		
Proplyene	664	746
Acetate (filament only)		
Acetic acid	223	241
Wood plup	216	234
Rayon (staple only)		
Wood pulp	570	628
Energy demand, synthetic fibers (kw-hrs. millions)		
Polyester	5,333	6,084
Nylon	4,332	4,853
Acrylic	2,221	2,490
Olefin	949	1,067
Acetate	1,749	1,894
Rayon (staple only)	2,475	2,723

[1] Includes the quantities used in nylon manufacture.
Source: Statistikon

stallment purchases. The consumer's attitudes towards the selection of goods and services is dynamic. During the early part of the inflationary period which began in 1973, the consumer abstained from expenditures on durable goods, as well as on apparel. His major expenditures were directed to food and gasoline. In the last few months, however, the consumer has returned to purchases of durable goods as well as textiles.

In was mentioned earlier in this article that the textile industry has, for a number of years, been the beneficiary of the socio-economic changes that took place in the economy. These changes resulted in a significantly greater percent of income spent to textiles with the net result of an increase in the per capita fiber consumption. The consumer has identified himself with textiles, as explained earlier in this article. Expenditures are dynamic and are subject to change when the consumer is faced with alternative outlays. Therefore, one of the primary functions of the textile management should be to maintain and further stimulate this consumer bias towards textiles.

Economic expectations for the year 1977 and partially into 1978, for a select series on the national economy and the textile industry in the U.S. and selected countries around the world, are presented in Table VIII. Actual shipments of the major fibers as well as their capacities for the period 1969 to 1976, with forecasts for the year 1977, are shown in Figure 9. On the same figure, along the graphs there is also a tabulation of the percent utilization of fiber producing capacities. The calculated demand for fiber petrochemicals, wood pulp and energy requirements to produce the indicated fibers is shown in Table IX. In general, demand for synthetic fibers, petrochemicals, energy and utilization of capacities is expected to increase during 1977. For the U.S. and the selected countries, the year 1977 will be a year of national and

textile business expansion (an exception to this is with textile business activity in Norway and the United Kingdom).

In the U.S., total expansion (GNP) for 1977 is an estimated 10.5% over 1976. This expansion is measured in current dollars. When this is converted to real dollar terms, the expansion will be an estimated 5%. This expansion will be balanced between all segments of the national economy. Real income expansion will be one of the stimulating forces for this total expansion and in addition to real income's normal growth, further expansion will be caused by the expected reduction in the growth of inflation and the upcoming tax rebate. Other stimulating forces will be the increase in total housing starts, expenditures on capital goods and various governmental programs.

Conclusions

The textile industry, one of the oldest industries, is experiencing a renaissance. The ingredients of making this industry one of the leading industries in the nation are there: economic stability, significant consumer support and major technological influx. There are some factors that still have not caught up with the industry's new status. Profits are still low, however, these are a function of the degree of adoption of the new technology. This is a matter of time. Productivity is relatively low. This poor performance is primarily related to the high labor turnover. Even though the industry is exposed and adopts technology developed outside, the industry itself is not very innovative. This factor should change. The industry has a poor public and business image. This is unjustifiable today because the textile industry is "sick" no more.

EXHIBIT 143 APPENDIX G

Article from *Textile World*

March 1977

USED CHUTE-FEED SYSTEM FOR CARDING SAVES SPRINGS $45,000 A YEAR

Machinery headed for storage got a second life in the Frances operation. Move got rid of unpopular jobs, eliminated 12 cards, and boosted output 10%. Chute feeding for cards pays off, whether the machinery is new or used. That's the experience of Springs Mills as it lived by its slogan, "maximum utilization of existing equipment."

The Frances plant, Fort Lawn, S.C., became the beneficiary of equipment removed in remodeling of another Springs plant. Originally, the machinery was ticketed for storage. Instead, Springs sent the entire chute-feed system to Frances and put it back to work. Here's what the move accomplished for the company:

° Reduced total cards in place from 36 to 24.

° Increased carding output by 10%.

° Saved an estimated $15,000 (annualized) by reduction of five jobs (a big plus in the current tight labor situation by cutting supply and repair costs at carding and picking by improving card sliver quality, etc.

Springs completed the installation of the used equipment at Frances at a fraction of the cost for new equipment. (Based on new equipment costs, Springs estimates the installation at Frances would have cost $2 million.)

In the process, Springs eliminated many of the big-muscle, unpopular jobs associated with lap handling.

Changeover began with removal of the calendar section from Frances' single-beater pickers (Hergeth). Springs put the vacuum system over the picker front to pick up the stock sheet and transfer it through ductwork to feed units at the card backs.

As cards, the feed units pass stock through a pair of guide rolls into the main card feel roll. Feed units have shaker plates and photoelectric controls to maintain necessary feed stock levels. As a safety precaution, ductwork has in-line, infrared smoke detectors.

Each of three pickers supports 10 cards (will support 12 if the need arises). Each duct line has by-pass valves that give the polyester-cotton blend plant almost infinite variation in the number of cards on each stock.

Frances got a big boost by bringing card production in balance with spinning requirements. With cards now averaging about a 40-lb. hr- (1S-kg/hr-) output, compared to an approximate 25-lb. hr- (11.25-kg/hr-) production in the old system, spinning no longer overruns cards.

Evener motions (Uster) at card fronts maintain sliver-weight levels within close tolerances and improve quality throughout the plant. In addition, thick-thin places and chokes, generally associated with lap laying and resultant damage to the card wire, have been eliminated. So have the expense and trouble of picker-front maintenance and repair, especially in the costly stack-roll area.

Another benefit is that the system itself keeps dust and lint confined within the chutes, therefore maintaining a much cleaner in-plant environment.

EXHIBIT 193, APPENDIX H

Daily News Record, May 20, 1977, p. 19

TOYODA O-E SPINNERS ACQUIRED BY 3 US MILLS

By Ralph Reynolds

CHARLOTTE—Three integrated U.S. textile mills have purchased second generation Toyoda open-end spinning frames with capabilities of spinning finer counts and consuming less energy than its predecessors.

The new systems were unveiled Thursday at a Tekamtex, Inc., open-house.

In an interview during the two-day open-house to acquaint the industry with the new machines, Toyoda product manager Sam White told DNR that three integrated textile plants in the U.S. had been operating the new open-end equipment for about two months. He refused to identify the mills.

White said a Model HSL 110 was in mill operation, spinning 5s to 10s in 100 per cent synthetics, a Model HSL 310, with trash removal on 10s, 100 per cent cotton, and a Model HS 120 spinning 30s to 40s of 100 per cent cotton.

According to White, the HS 120 is designed to run finer counts, up to 45s, economically at higher rotor speeds, up to 50,000 rpm on a 50-mm diameter rotor. This compares with a 65-mm diameter rotor on the existing Model BS machine, of which there are over 200 operating in the U.S., he said.

The break-even point in spinning on the new version is in the mid-30s count range, compared with the 20s range on the older Model BS. "The HS 120 could

open new doors in finer counts for such applications as print cloth and gauze," White said.

White estimated the cost of the HS 120 as about $450 per position, compared with about $350 for the Model BS. The Model HS has 200 rotors.

Responding to a query on energy savings through less power consumption, White cited as an example the HS 120 with the smaller rotor operating at 45,000 rpm, 200 positions would use the equivalent power of a Model BS with 200 positions at 36,000 rpm.

The HSL 310, the larger diameter rotor for coarser counts in the 3s to 30s range, costs approximately $700 per position with the trash removal device, about $600 per position without the device. By comparison, some competitive open-end spinning machines with trash removal are quoted at up to $1,000 per position. The HSL series has 140 rotors.

White said the addition of the trash removal device didn't change the Toyoda philosophy of the need to clean prior to open-end spinning, but offered the customer a choice. Using the trash removal device on equivalent stock, the rotor cleaning cycle can be extended about three times so that if one is normally cleaned once each eight hours, it could go to once every 24 hours, White explained.

Also offered on the HSL series is capability to take up on a 3 degree, 30 minute cone, 5x12-inch diameter, 7.5 pound package on cotton, in addition to the standard encese. The 14x36-inch can hold about 31 pounds of cotton.

Also optionally available are a tailing transfer device and a waring attachment.

In addition to the second generation of open-end spinning, Tekamtex showed its Model CKW tandem card de-

signed for production speeds to 100 pounds per hour (pph) and featuring efficient removal of microdust, and the Model CK-7C single card for 100-110 pph production. The cards are said to provide efficient trash and dust removal resulting from the special design around the lickerin, plus the type and arrangement of the wire card clothing, White said.

A planetary coiler is offered for the first time on the cards and an autolevelling device will soon be available, White pointed out.

The Model D-2PL drawing frame, also on display, uses 9.12 or 14-inch diameter cans. Equipped with the pantograph system to compress silver, about 50 per cent more stock can be fed into the cans than with conventional systems.

Also attracting attention from textile executives, according to White, was the Model FL-6 roving frame, which has a semiautomatic doffing mechanism that cuts doffing time to one-half that of conventional frames.

* * * * *

EXHIBIT 160

Post-Hearing Comment of the American Textile Manufacturers Institute, Inc.

* * * * *

III. *Medical Surveillance*

In regard to medical surveillance of employees, it is clear that the standard which ultimately issues should include requirements regarding a medical surveillance program. The threshold question is whether employers should be required to institute and maintain the medical surveillance programs or whether some outside agency should be responsible for the implementation, administration and maintenance of such a program.

In view of the evidence of record, it is submitted that there can be little question that the textile industry is capable of administering medical surveillance programs for its employees in regard to their exposure to "cotton dust." As a matter of fact, a considerable portion of the evidence of record regarding all aspects of the standard, but particularly medical surveillance, was submitted by medical directors of companies in the industry who have instituted and administered medical surveillance programs for a number of years.[57] In the face of the foregoing, there is no justification for any approach other than that of the companies in the industry maintaining their own medical surveillance programs whether these programs are under the supervision of the medical directors of the companies or utilize physicians, specifically pulmonary specialists, who are not in the employ of the company.

It is recognized that any medical surveillance program regarding employee exposure to cotton dust must, in view of the definition and categorization or classification of

the varying symptoms of byssinosis, require the administration of a questionnaire and pulmonary function tests. These two requirements, however, must not and cannot be utilized, as is apparently the approach in the Proposed Standard, as a substitute for the exercise of a physician's independent medical judgment in the diagnosis and treatment of employees. Regrettably, the Proposed Standard appears to take a "by the numbers" approach in regard to the medical surveillance program and makes every effort to "quantify" specific levels or changes in pulmonary function requiring additional action which are completely unrelated to the *individual*'s pulmonary function. This approach is particularly evident in regard to the utilization of predicted values set forth in Appendix C to the Proposed Standard.[58] It is submitted that these predicted values should not be utilized. This particular issue will be treated in some detail below. At this juncture, it will suffice to point out that there was considerable evidence produced at the Hearing that the predicted values set forth in Appendix C of the Proposed Standard bear little if any relation to the predicted values encountered by the textile industry.[59] Moreover, the utilization of predicted values raises the issue of the treatment of the significant difference in lung function between races,[60] a differential which received considerable attention at the Hearing and for which, other than a flat percentage adjustment such as reflected in the Proposed Standard,[61] there appeared to be no viable treatment. It is clear, however, that without such adjustment an enormous number of black applicants will be rejected by companies in order to avoid any possibility of continuously retesting (every six months under the Proposed Standard [62]) employees who, based on their own racial characteristics, do not indicate a deficit or decrement in pulmonary function, but who are not within, for example, 80% of the predicted value in Appendix C.

A. *The Questionnaire*

As pointed out above, it is recognized that the administration of a questionnaire should be required as part of any medical surveillance program in connection with employee exposure to "cotton dust." A number of critical issues, however, are involved in the nature of the questionnaire, the intervals between which such questionnaire should be given, the efficacy of continuous repetition of the questionnaire and the importance which should be ascribed to the subjective responses to the questions, and, finally, by whom the questionnaire should be administered.

Initially, it must be emphasized that the questionnaire must be regarded *solely* as a tool to aid the supervising physician in the diagnosis and treatment of the individual. This is particularly true in regard to the subjective responses which would indicate that the individual has the subjective symptoms of Grade ½. As pointed out above, Grade ½ has questionable validity and certainly should not be considered as a conclusive diagnosis of byssinosis.[63] Further, the use of questionnaire is subject to a multitude of variables, including the employee's recollection (particularly in regard to Grade ½'s "occasional" chest tightness on Mondays), the objectivity of the administrator of the questionnaire, the variability of results obtained by varying inflections utilized by the interviewer [64] and the fact that, in numerous studies, positive responses to the questions regarding chest tightness and/or breathlessness were elicited from employees who were not exposed and had not been exposed to cotton dust.[65] Moreover, from a clinical standpoint, the lack of correlation between the subjective responses to the questionnaire and the deficit or decrement in pulmonary function raises severe questions, notwithstanding the classical definition of the disease, as to the conclusiveness of the diagnosis, particularly in regard to Grade ½, and, thus, the appro-

priate treatment, surveillance or handling of the individual involved.

There can be no question that any medical surveillance program must, in regard to *newly hired employees*, provide for the administration of the questionnaire. A significant question arises, however, in regard to the repeated use of the questionnaire in view of the numerous problems associated with its administration, including, but not limited to, those set worth above. Specifically, a significant issue arises in regard to the duration of time between which the questionnaire is administered and particularly in regard to employees who exhibit signs of significant deficit or decrement in pulmonary function. The Proposed Standard requires the annual administration of the questionnaire and in the event the employee exhibits certain deficit in pulmonary function in regard to predicted values or drop in pulmonary function, as measured by FEV_1, post versus pre-shift, semi-annually.[66]

In view of the foregoing, ATMI submits that it would be preferable and appropriate that the questionnaire only be administered to employees at the time of their second annual pulmonary function testing following their initial employment. In view of the experience in at least one study even this interval may be too short to be of any value as the time may not be sufficient for the subjective reaction to develop and, thus, subjective response to be elicited.[67] Presumably, the questionnaire would be administered at the same time as the pulmonary function testing was done at the plant. Thus, although the question of the employees pulmonary function would be addressed annually, the time spent administering the extensive questionnaire and the difficulties associated with the repetitive use of the questionnaire would be minimized. For there can be little question at this juncture that the questionnaire should serve to identify employees with clear acute or reversible symptoms in order that

some action may be taken in regard to their situation, not for a conclusive diagnosis of their condition.

A similar approach should be applicable in regard to employees who are identified, as a result of *replicated* results from pulmonary function tests, as having significant decrement in post-shift versus pre-shift FEV_1, FVC or in *their* base-line measurements. These significant decrements or shifts are discussed below. In this regard it is submitted that, although these employees should receive pulmonary function tests more often than annually and should be followed closely on a clinical basis, it is unnecessary to repeat the questionnaire with these employees on a six-month basis as indicated by the Proposed Standard. The reason for this position should be obvious. It serves no useful purpose to continue to ask employees similar questions regarding their situation when that situation has already been determined.[68] Accordingly, at the minimum, the questionnaire should not be given to employees who exhibit significant decrements or deficits in the pulmonary function measurements set forth above except on an annual basis.

It must be emphasized that underlying the foregoing approach to the intervals between administration of the questionnaire is the basic fact that the questionnaire must be regarded as a tool of medical surveillance, not as a conclusive diagnosis,[69] and that *objective* evidence of the individuals condition, specifically pulmonary function tests results, are much more indicative, once the indivdiual is identified, of the individual's condition and its improvement or deterioration.[70]

It is apparent from the evidence of record that there is considerable confusion regarding the questionnaire which is set forth in Appendix B to the Proposed Standard.[71] Moreover, the validity of the questionnaire set forth in Appendix B must be questioned in view of the considerable testimony that the questionnaire was *not*

the British Research Council questionnaire, as modified by Schilling,[72] left out a considerable number of questions of definite relevance to the individual's condition as it related to byssinosis and the diagnosis thereof [73] and may or may not have been the questionnaire suggested by the British Occupational Hygiene Society in 1972.[74] Specifically, objection to the questionnaire is raised in regard to a number of questions which are omitted, particularly those related to allergies and asthma, the lack of questions regarding "cough" as to *when* the "cough" occurred on Monday and the addition of questions regarding the employee's subjective condition following return from vacation which, in the textile industry, is for at least one week and which all employees, with minimal exception, take at the same time.[75]

It is submitted that the questionnaire which should be utilized is either a questionnaire such as one submitted by Dr. Whitworth of West Point Pepperell [76] which would be uniformly used throughout the industry and which, although lengthy, provides considerable information concerning the employee's respiratory condition and, thus, permits a superior clinical evaluation of the employee's condition, including the possibility of byssinosis, *or* the British Medical Research Council questionnaire as modified by Schilling, in order to maintain some form of historical perspective and relationship to previous studies so that, in turn, the progress and efficacy of the implementation of any new standard may be evaluated. The proposed Appendix B satisfies neither of these alternatives as it, as pointed out above, omits numerous questions and adds new ones, thereby distorting any clinical evaluation and historical perspective. Moreover, the questionnaire set forth in Appendix B is so structured that it, on a comparative basis and particularly in view of the omissions regarding allergies, asthma and other respiratory problems, forces a "diagnosis" of byssinosis by preventing any other variable or possible problem to be ade-

quately considered. Finally, in view of the demonstrated lack of knowledge of the causative agent of byssinosis and a *precise* definition of the disease for purposes of diagnosis, clinical and otherwise, it is submitted that any questionnaire which, by its structure, limits questions relating to other forms of respiratory ailments and fails to pinpoint important factual information, particularly regarding the symptomatology or lack thereof on Mondays, must not be utilized. As Dr. Martin pointed out during the Hearing, it is inconceivable that an effort should or could be made to limit the number of questions of employees exposed to the "agent," in the broadest sense, causing a disease which has so many unknown factors.[77] Such approach is completely contrary to reason and will, it is submitted, do little to achieve the protection of employees from material impairment of their health which is required on either a humane basis of under the Act.

Finally, in regard to the administration of the questionnaire, there can be little dispute that persons, including nurses, technicians, and others, can, properly administer the questionnaire.[78] This conclusion is made, of course, with the *caveat* that these individuals are adequately trained to avoid the various problems, *e.g.* voice inflection, explanation of question, etc.[79] which could lead to distortions in the responses of the employee. The evidence of record is overwhelming, however, that the administration of the questionnaire can be performed by nurses, technicians, and lay personnel, if trained, as capably as physicians,[80] if not more so.

B. *Pulmonary Function Tests*

As in the case of the questionnaire, and perhaps to a greater extent, it is clear that the administration of pulmonary function tests for all employees exposed to "cotton dust" must be an integral part of any medical

surveillance program. Similar comments to those regarding the questionnaire must be made, however, in regard to the Proposed Standard's approach to the utilization of the results of the pulmonary function test, particularly as they relate to the application of predicted values for FEV_1 and FVC, including the "Prediction Nomograms" set forth in Appendix C of the Proposed Standard.

It is submitted that the utilization of the nomograms set forth in Appendix C and the requirement requiring "a detailed examination" for all employees whose FEV_1 is less than certain percentages of predicted values are totally inappropriate and must be rejected.[81]

First, the prediction monograms set forth in Appendix C are for a non-textile industry population [82] and, as clearly revealed by unrebutted evidence of record, bear no relation to white or black employees in the Southeast.[83] Further, the prediction nomograms of Kory *et al.*, those in Appendix C, have an enormous Standard Error of Estimate.[84] Substitution of other prediction monograms would, however, also be totally inappropriate in view of the lack of relationship to employees in the Southeast or because such monograms, such as those of Morris *et al.*,[85] are for non-smokers, a population clearly not reflective of the population of the textile industry where a large percentage of employees smoke and smoke heavily.

In addition, it is manifest that the principle behind the utilization and requirement for periodic pulmonary function testing is the determination of changes, significant changes, in the *individual's* respiratory function. It is not for the purpose of determining whether a textile employee population, as a group, compares favorably to predicted values. Thus, the critical determination which must be made in order to diagnose and treat the individual's condition is one which reflects the *individ-*

ual's change over a period of time. Aside from the obvious logical validity of this position, it is clear that the Act, specifically Section 6(b)(5), requires protection of the employee over his working life.

Finally, the utilization of predicted value for the purposes set forth in the Proposed Standard, specifically the requirement of re-examination every six months, can only result in the rejection of numerous applicants for employment. This result follows because there is little question that, if an applicant has an FEV_1 of less than 79% (curiously the Proposed Standard makes no provision for an employee with an FEV_1 of 80% of predicted value) at the time the *initial* pulmonary function test is administered, and that individual at his first annual examination has *no* change whatsoever, the Standard requires that the individual have a re-examination six months later, plus *the re-administration of the questionnaire.* This result, particularly in view of the fact that a massive number of applicants in the Southeast have an FEV_1 of less than 79% of predicted value, is both incomprehensible and irrational. It can be acceptable to no one.

If any consideration can be given to the predicted values, the utilization of such predicted values must be extremely restricted. Moreover, if predicted values are to be used, then there is no question that they must be adjusted as set forth in Appendix C by 15% for black employees. The evidence of record is overwhelming that there is a difference in lung volume [86] and to fail to take into account such differences, for whatever reason they may occur, would be unconscionable. Such failure can only lead again to rejection of a large number of healthy individuals as the textile industry, as is the case of any employer, does not wish to be placed in the position of reexamining, either by questionnaire or pulmonary function test, employees who show little or no change or dec-

rement in pulmonary function but whose predicted values do not fit in with norms inapplicable to them.

It is no answer to the problem posed by differences in lung function between races to utilize a FEV^1/FVC ratio. This approach, at least as the *sole* method of adjusting for such differences, was rejected for a variety of reasons by virtually all of the various physicians who testified at the Hearing. For example, Dr. Weill regarded it as totally unsatisfactory; Dr. Martin rejected it on the basis it could not be used exclusively; and Dr. Whitworth regarded it as invalid unless there was a limit of acceptance on the FVC itself.[87]

In regard to the criteria to be utilized in connection with the re-examination of employees, it must first be emphasized that the Proposed Standard, once again, adopts a rigid "by the numbers" approach without regard for independent medical judgment or the actual level of the individual's pulmonary function. Moreover, it appears to reflect a presumption or conclusion that byssinosis can be diagnosed *solely* by pulmonary function testing. As pointed out above, such presumption or conclusion is without any support or validity.[88] ATMI submits that the criteria for pulmonary function testing on other than an annual basis must reflect the individual's standardized base-line levels and the change therein.

First, all employees' baseline FEV_1 or FVC, either on initial or any subsequent examination, must be determined by standardized methods with a clear indication of which value will be utilized. In this regard, ATMI suggests that the recommendations of the American Thoracic Society be carefully reviewed and that the Standard indicate that these recommended standards be followed as *guidelines*, if possible. Moreover, it must be emphasized that any standard must specifically set forth which values, be they maximal or mean, which must be considered in comparing any and all pulmonary function

tests.[89] Further, in view of the tremendous variability in the values obtained from day-to-day in an individual's pulmonary function test,[90] in some cases as high as 200 cc's,[91] it should be clearly specified that no test results should be utilized for the determination of re-examination or otherwise unless such tests are replicated. This is particularly true in view of the margin of error built into the various spirometric devices utilized.[92] In this latter regard, it must be noted that in contrast to the too detailed and excessively restrictive requirements of Appendix A in regard to sampling procedures, there are absolutely no procedures set forth in the Proposed Standard which could be utilized as guidelines to attempt to obtain accuracy and minimize the margin or error in pulmonary function equipment.[93] This omission is extremely significant in view of the fact that the variation in "blows" for an individual can be considerable and the determination of the mean values of, for example, FEV_1, should only be made if there are at least three "blows" which show a definite similarity, e.g. a level within 10% of each other.[94]

In regard to the criteria to be utilized in the determination of whether a re-examination of an employee is required on less than an annual basis, ATMI submits that the criteria should be as follows:

1. A decline in baseline FEV_1 totaling 5% greater than the predicted decline or 200 milliliters, whichever is less.
2. A decline in baseline FVC totaling 5% greater than the predicted decline or 200 millileters, whichever is less.
3. A decrement in post-shift FEV_1 of 10% or more or 200 millileters, whichever is less, from pre-shift FEV_1.

In the event the employee meets any of the foregoing criteria, the questionnaire should be administered. In the event that the employee's subjective responses to the questionnaire indicate that the employee may be categorized or classified in one of the acute or reversible grades of "byssinosis," the employee should be issued and required to wear a respirator, without regard to the "cotton dust" levels to which he or she may be exposed.

In the event that the employee, on re-examination during or at the end of a six-month period, which re-examination would not include the administration of another questionnaire, continues to demonstrate a decline or decrement in excess of the criteria set forth above, the employee should be referred to either an outside physician, or physician on the corporate medical staff for an extensive pulmonary examination and clinical evaluation.[95] The ultimate assignment of the employee should be based on the recommendations of such physician.

In regard to the question of transfer of employees to "lower-risk" areas, it must be emphasized that such transfer should be effected only with the employee's agreement and only after consideration is given to a multitude of factors, including age, length of employment in the present area and the extent of decline or decrement in lung function.[96] This approach, utilizing both medical judgment and efforts to minimize the effects of the employee's removal from a familiar environment, also permits a clear determination that the employee's condition is a result of *exposure to conditions over a period of time.* Specifically, exposure to "cotton dust" has resulted in "an accentuated loss of lung function."[97] To do otherwise could require the wholesale movement of a number of employees to low dust areas, an unnecessary disruption of all employees, and a failure to make a clear evaluation that the employee's condition was due to exposure to "cotton dust," not the result of

smoking or some other activity or agent unrelated to occupational exposure. Finally, this approach avoids precipitous action which can only serve to disrupt the individual employee's working place without affording sufficient time to make determinations, such as the effectiveness of the use of a respirator, which may permit such disruption to be avoided.

C. *Physician's Written Opinion and the Furnishing of Information*

Although not extensively treated at the hearing, the provisions of the Proposed Standard relating to these subjects [98] are totally objectionable. ATMI's basic position is set forth in its Objection and Arguments No. 6.[99] It must be emphasized, however, that these provisions, although an apparent attemp to maintain confidentiality, except in relation of occupational exposure to "cotton dust" and resulting pulmonary problems, fail to achieve any objective other than to tie the hands of the examining physician in attemping to treat the employee. This result is apparently caused by OSHA's disregard of, for example, the effects, either causal or addictive, of smoking, clearly non-occupational, in relation to byssinosis and other pulmonary diseases such as chronic bronchitis. These non-occupational causes and effects, assuming they could be set entirely aside from occupational, have considerable relevance, to say the least, in making recommendations regarding the individual. Thus, they cannot, as the Proposed Standard is wont to do, be clearly separated.

Accordingly, these provisions, except to the extent they require advising the employee of the results of the examination, must be deleted.

* * * * *

Dr. Imbus, a physician who has as much experience as any other member of the medical profession regarding medical surveillance programs, particularly in the textile

industry, indicated that a manageable situation under a medical surveillance program "in terms of transferring people" or "reassigning" people would be less than 10%.[160] Thus, even assuming the validity of utilizing the various prevalence studies and without regard to the duration or level of the past exposure, it is clear that less than 10% of the total number of employees covered would be subject to transfer in circumstances in which the cotton trash dust levels, as measured by a vertical elutriator, were less than .5mg/m³ in the processes of opening through roving. Consequently, an unmanageable situation would not be created if the permissible exposure limit for the opening through the roving process was set at .5 mg/m³.

* * * * *

IX. *Conclusion*

In summary, ATMI submits the following:

1. The standard, particularly the permissible exposure limits, should be directed to the prevention of Grade 3 byssinosis or, as the British Standard is evidently directed, the prevention of irreversible symptoms.

2. In view of the extreme variability of the subjective symptoms, particularly Grade 1/2; the unknown causation agent and pathology; and the apparently considerable variation in individual susceptibility to "cotton dust," particularly as indicated by the low level of correlation of prevalence of byssinosis with dust exposure in employees who do not smoke, medical surveillance must be regarded as the primary means of protecting the health of employees exposed to "cotton dust," with engineering controls and work practices considered an adjunct thereto for the purposes of controlling dust levels to a point at which medical surveillance programs are manageable.

3. Although the causation agent of byssinosis is unknown, the definition of "cotton dust" in any standard must accurately and definitively reflect the substance

regulated or the substance which, in this case, at least contains the causative agent. Specifically, the controlled or regulated substance should be "cotton trash dust" or "raw cotton dust." The definition must not and legally cannot include dust from sources which have not been shown to be "toxic materials" or "harmful physical agents."

4. Although the administration of questionnaires and pulmonary function tests should be required as the part of any standard, the standard should not and cannot, in view of the evidence of record, rely on predicted values for determination of the pulmonary function of employees in the Southeast, particularly in the textile industry, and cannot be used in the determination of whether more frequent pulmonary function tests or examinations should be administered. Further, the intervals between administration of the questionnaire except for employees with significant decrements or deficits in pulmonary function, should be considerably greater than the one year period set forth in the Proposed Standard.

5. The permissible exposure limits should be different for different areas of the textile manufacturing process. Specifically, the permissible exposure limits should be the following *mean* cotton trash dust levels: .5mg/m^3 in the processes from opening through roving; .5 mg/m^3 in the yarn production processes of spinning, twisting, winding, spooling and warping; and 1.0 mg/m^3 in the processes of slashing and weaving. Such levels are totally appropriate and reasonable in view of the factors referred to in subparagraph 2 above; the clear reduction in toxic potential of the dust generated by the processing of cotton in the later processes, particularly yarn production and weaving; the various studies which clearly reflect a low or extremely low prevalence in the later processes; the manageablility of the number of employees who may exhibit the symptoms of byssinosis in the face of such permissible exposure limits; and the lack of tech-

nological and economic feasibility in the later processes of yarn production and weaving for achieving, by engineering controls, lower limits.

6. The permissible exposure limits set forth above should not be required by the standard to be achieved by engineering controls in a period of less than seven years, particularly in view of the lack of capacity of the vendors of the dust control equipment required in order to achieve such levels [242] and the enormous capital requirements which such limits impose on an industry whose capacity to raise prices to levels to maintain return on investment is questionable and which is also faced with enormous capital requirements for compliance with other federal standards promulgated by OSHA and other federal agencies.[243]

7. The final standard should not require, as the Proposed Standard does, massive and onerous paperwork, particularly regarding work practices, mechanical ventilation and monitoring, which detract from the ultimate objectives of the standard and which, in compliance situations, have little, if any, value.

8. The final standard should give equal weight to the utilization of engineering control, work practices and the use of respirators, particularly single-use respirators, in regard to achieving the permissible exposure limits. To do otherwise could result in the economic crippling of the entire textile industry, a result not contemplated by the Act, nor in the interest of anyone.

EXHIBIT 171

Letter from F. S. Love to Eula Bingham

July 15, 1977

Ms. Eula Bingham
Assistant Secretary for
Occupational Safety and Health
U.S. Department of Labor
Washington, D.C. 20210

Dear Ms. Bingham:

With further reference to your recent correspondence with ATMI and specifically with reference to our letter to you of July 11, we are pleased to enclose additional information which we hope will be of assistance to OSHA in evaluating the testimony presented by ATMI at the recent OSHA hearing regarding a standard for raw cotton dust. We believe that the information now being submitted is fully responsive to your request as outlined to us in a letter to Mr. Robert P. Timmerman, President of ATMI, dated June 30, 1977, and that it is in accordance with the agreement reached between ATMI attorneys and the office of the solicitor for the Department.

Included in the material being sent you with this letter are copies of all of the individual responses received by ATMI in answer to a questionnaire distributed for the purpose of collecting engineering data. With regard to these individual responses, the following alterations have been made in accordance with our agreement with the solicitor's office:

1. Because their sequence could be used to identify the number of plants in one company, the code numbers originally found at the top of page one have been deleted.

2. Since cotton consumption would be useful to an expert in identifying a given plant, the number of

bales consumed has been deleted in answer to Question No. 1 and a range has been used to indicate less than 10,000 bales ($< 10{,}000$) and more than 10,000 ($> 10{,}000$)

3. For a similar reason, the plant capacity figure in answer to Question No. 2 has been deleted and a range has been substituted for less than 100,000 pounds and more than 100,000 pounds.

4. Again, the speed of cards is also a plant identification factor and a range has been used of less than 30 pounds per hour; between 30 and 60; and more than 60 pounds.

5. The number of spindles provided in answer to Question No. 12 has been deleted and the yarn count has been specified as coarse (0-30); medium (30-50); and fine (above 50).

6. The number of looms provided in Question No. 14 has been deleted.

7. In the relatively few instances in which comments were provided in answer to Question No. 22, these have been deleted because they referred to special circumstances within that plant which might be used by engineers and others to identify the plant.

Regarding the summary of ATMI medical testimony, we are providing the consolidated data which was furnished to ATMI by individual companies and which constituted the basis for such summary testimony. With regard to this information, the following should be noted:

1. The name of the company and the name of the doctor have been deleted.

2. The raw material and the yarn counts have been deleted, with the latter being designated the coarse, medium and fine ranges specified above.

3. Footnotes have been attached for an explanation of accountability.

We are confident that a careful study of the enclosed information will fully and completely substantiate the validity of the ATMI testimony.

We are pleased to have the opportunity of providing it for you and for this purpose.

Yours sincerely,

/s/ F. S. Love
F. S. LOVE
Secretary-Treasurer

mvm

C/ Mr. Robert P. Timmerman

*NO PLANT NAME, COMPANY OR LOCATION SHOULD BE INDICATED

QUESTIONNAIRE TO ATMI MEMBER COMPANIES
TO PROVIDE INFORMATION IN ORDER TO DETERMINE
ECONOMIC IMPACT OF MEETING CURRENT AND PROJECTED
COTTON DUST STANDARDS

PLEASE COMPLETE ONE FORM FOR EACH PLANT LOCATION
(Yarn Manufacturing Facilities and Subsequent Griege Processes)

1. Number of bales of cotton consumed during the 12-month period August 1, 1973 through July 31, 1974 [redacted]. <10,000

2. Please indicate approximately total normal full capacity of plant to nearest 25,000 pounds per week [redacted]. <100,000

3. Yarn processed as a percent of total.

100% Cotton 100 % Avg. Grade 4/3 Avg. Micronaire 3.8

100% Synthetic — %

Cotton/Synthetic Blends — % (% of Cotton in Blends — %)

4. Number of workers employed in: (cotton and cotton blend production only)

3	Opening	78	Spinning	—	Knitting
3	Picking	23	Yarn Prep.	23	Cloth Room
21	Carding	165	Weaving	1	Waste House

5. Opening:

No. of Opening Hoppers 6.

Are Hoppers hand fed from bale lay down? Yes 4 No —

No. of Waste Machines 2.

Total No. of Condensers of all kinds in the room 2.

If automatic feed, are bales placed by hand —, lift truck —?

6. Picking:

No. of Pickers 2.

No. of Hoppers per Picker —.

No. of Beaters per Picker 1.

Total No. of Condensers of all kinds in the room 7.

No of Waste Machines —.

7. How is material moved to cards? Chute fed _____ Lap fed ✓

8. Carding:

Cotton cards:	Number 49	Rate 130 lbs. per hr.
Synthetic cards:	Number —	Rate _____ lbs. per hr.
Cotton/Synthetic blend cards:	Number —	Rate _____ lbs. per hr.

9. Drawing:

Breaker Drawing	Yes ✓ No _____	No. of deliveries 10
Finisher Drawing	Yes ✓ No _____	No. of deliveries 6
CAT DRAWING	YES ✓	NO. " " 10

10. Roving:

No. of Frames —.

No. with "broken-end collection system" —.

11. Combing:

Yes ✓ No _____ No. of machines 7.

No. of machines with vacuum noil remover —.

12. Spinning:

No. of Frames 93. No. of Spindles [redacted].

No. of Frames with central air return 93

Approximate Average Yarn Count [redacted]. 4/1 NE

13. Yarn Preparation:

	Yes	No	No. of Machines
B/C Spooling:	✓	—	2
Winding:	—	✓	—
Twisting:	—	✓	—
No. of Twisting Spindles:	—	—	—
Warping:	✓	—	—
No. of Warpers with suction cleaned creel:	—	—	—
No. of Warpers with suction cleaned comb:	—	—	—
Quilling:	—	✓	—
Slasher:	✓	—	1

Sizing: What type used Starch ✓ PVA, etc. ✓

14. Weaving: Yes ✓ No ____ No. of Looms [redacted]

15. Knitting: Yes ____ No ✓ No. of Machines ____

16. Cloth Room: Yes ✓ No ____

No. of Brushers — No. of Shears 1

17. Waste House: No. of Bale Presses 1

Is waste moved to waste house from: Openers - By Hand ✓, Automatically ____, Cards - By Hand ✓, Automatically ____?

Is waste baler filled: By Hand ✓, Automatically ____?

If waste is conveyed to waste house automatically, is it collected in overhead drop tank ____, others ✓?

Operator hours per shift required to bale waste US 5

18. Air Conditioning: (Please indicate type air conditioning used in plant.)

Process Area:	Refrigerated	Evaporative Cooling	Type Filter (identify media where possible) Lint Screen	Self Cleaning or Drum	Additional V-Screen	Roll-up Paper	Electrostat
Opening	✓			TRK			
Picking	✓			"			
Carding	✓			"			
Spinning	✓			"			
Yarn Preparation	✓		TRK				
Weaving	✓	(AIR WASH)					
Knitting							
Cloth Room	✓				TRK		
Waste House	(VENTILATION)		TRK				

19. Air Movement:

Process Area:	No. of Rooms	Supply Air Total CFM	Floor Area Total Sq. Ft.	Ceiling Hgt. Total Ft.	Is air removed from the room thru: Wall Vents	Ceiling Vents	Floor Vents	Machine Orifices
Opening	1	78,000	5,532	20		✓		
Picking	5					✓		
Carding	1	64,000	19,960	20				✓
Spinning	1	177,000	51,800	"			✓	
Yarn Preparation	5							✓
Weaving	1	212,600	65,355	20	✓			
Knitting								
Cloth Room	1	27,500	8,556	20				✓
Waste House	1	10,260	5,250	"	✓			

20. Type Filter Media Employed in Machine Suction Cleaning (machine cleaning systems):

Process Area:	Machine Suction Cleaned		Is Air Returned To:		Type Filter			
	Yes	No	Room	AC	Lint Screen	Drum	Bag	Additional V-Screen
Opening	—	✓	—	—	—	—	—	—
Picking	—	✓	—	—	—	—	—	—
Carding	✓	—	—	✓	—	✓	—	—
Spinning	✓	—	—	✓	—	✓	—	✓
Yarn Preparation	—	—	—	—	—	—	—	✓
Weaving	—	✓	—	—	—	—	—	—
Knitting	—	—	—	—	—	—	—	—
Cloth Room	PARTIAL	—	—	✓	✓	—	—	—
Waste House	—	✓	—	—	—	—	—	—

21. Do you tentatively expect to purchase instrument for the measurement of the amount of air taken into and exhaled from the lungs (FEV_1 and FVC) required under the medical surveillance program for employees exposed to cotton dust? Yes ✓ No ____ Or do you expect to use consultants to perform this type of service? Yes ____ No ✓

Have you already purchased the equipment to measure FEV_1 and FVC? Yes ✓ No ____

In determining cotton dust levels in your work area, do you plan on using in-house capability for the weighing, sampling, etc., or having this service provided by outside consultants? In-House ✓ Outside Consultant ____

22. Additional comments on any questions asked above: ____

*NO PLANT NAME, COMPANY OR LOCATION SHOULD BE INDICATED

III. TRANSCRIPT OF HEARING BEFORE THE AGENCY

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[167]* DR. BOUHUYS: I think perhaps that I should mention that I am a member of Permanent Commission and International Association for Occupational Health, that I serve as Chairman of the subcommittee on Byssinosis on the Permanent Commission.

I have studied byssinosis since 1958, first in Sweden and the Netherlands and, initially it was—I began these studies and I found this story of shortness of breath experienced by people mainly or only on Monday a rather unbelievable story.

At that time I had no experience in the work environment myself. I decided to take a sample of cotton dust to the laboratory from a mill. My colleague, Dr. Lendeim and I held an extract of that dust. We thought that we would prove that nothing happened and that whatever these workers were complaining of had nothing to do with cotton dust.

We were proven wrong in about 20 minutes time. Both of us became very short of breath, had abnormal lung function tests and since that personal experience which I have repeated a number of times since then, I have been fully convinced of the toxic effects of cotton dusts or agents in cotton dust.

These laboratory studies have been extended later with field studies which started in the Netherlands and in Sweden on population groups of cotton mill workers in various types of mills. In 1966 I examined, together with Schelling and Wellborg [168] a group of mostly retired cotton textile workers in the United States. We identified about a dozen people, all men, who were prematurely disabled, meaning that they were or had disabling lung function loss in our judgment and had retired from the work force well before the age of 65.

This study led to field surveys of workers in cotton textile mills in the U. S. where we did lung function

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* Bracketed numbers refer to the page of the reporter's transcript of proceedings.

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studies before and after work, on Mondays measurements of dust levels in the mills.

These results showed that the acute stages of this disease, byssinosis, consisting of chest tightness and shortness of breath, and a decrease in lung function on Mondays, sometimes also on other days, occurred in some 20 to 30 percent of the carding room workers in different mills and also at variable proportion in spinning and winding workers.

Now, these things are usually stated in the form of answers to questionnaires, numbers obtained at lung function tests. I just want to stress that those things are very important and they provide documentation of what goes on.

I think it is important to stress that I and others who have done similar studies have seen these workers at the end of the work shift, have noticed their labored breathing at the end of a work shift in a work room where there is a risk of byssinosis so there is just no doubt in my mind that there is a serious health hazard here judging from these acute effects.

[169] The work that we did in the epidemiological studies in U.S. cotton textile mills was discussed during the second international conference on byssinosis in 1968 and, together with results from other studies, led to a recommendation by myself and Dr. Gilson, Dr. Schilling that the then existing thresher limit value which was one milligram per cubic meter total dust needed to be revised downward and that a new limit should be placed on respirable but not on total dust.

We also suggested a plan for medical surveillance of cotton textile workers but at this point I would like to say, to a large extent, the proposal is now under consideration, fulfills the kind of needs that we saw at that time, in general and also in many details and I would like to say that I support most of the provisions of the standard and believe that they will contribute, if fully implemented, greatly to improve health of cotton textile workers.

In the meantime, additional studies, elaborate studies in U.S. cotton textile workers were being done since about 1966 or 1967 by Merchant et al and also later by Brown et al. These studies have covered many thousands of active workers and between them by and large confirm that byssinosis was, at that time and still is, highly prevalent disease among cotton textile workers, and, in particular among workers in opening processes, carding and spinning although there are data in one of Merchant's studies on what I consider a significant prevelance [170] of byssinosis among weavers as well as among those in the earlier processing.

Now, there has been considerable discussion about these acute responses to cotton dust exposure. That is chest tightness and other symptoms as well as the acute drop of lung function on Mondays.

One needs to do carefully standardized lung function tests to detect these relatively small decreases of FEV one, for instance, that occur in the course of a work shift on Monday. When one studies a group of workers, one finds a highly significant decrease, even though it may be small, if it occurs systematically in a sufficient number of people.

The medical surveillance requirements of the proposed standard, however, relate to judgments about individuals, not groups. In my comments, I have suggested that the criteria for a meaningful decrease of FEV one might perhaps better be set at an absolute value I have proposed 0.20 liters rather than five percent of the initial value.

This is a slightly less stringent cutoff level, slightly less stringent for all those whose initial FEV one of less than four liters, and I think that such a limit can indeed be detected in the individual if tests are done with care. If there is any doubt, whether we've given personal response to this degree or not it is quite simple to repeat the test procedure on another Monday and find out whether indeed a consistent response.

[171] I believe that provisions in the standard in this respect are good ones and that they indicate the groups

that are most at risk as candidates for regular medical surveillance.

I think that in this way the standard does not impose need for periodical medical surveillance on a large percentage of people whose lung function is normal and who do not react significantly to dust exposures on Mondays.

I would like to emphasize also, although we've heard a lot already today about differences between various studies and studies done by different investigators, in my estimation, the similarities between most of these studies are much more striking than any differences and that, by and large, these studies of byssinosis that have been done all over the world show a very strikingly similar prevalence and actually the dose response relations that are referred to also do not vary to such a degree that it becomes impossible to figure out some reasonable level below which the risk becomes reasonably small.

I believe the standard has chosen a compromise level but I think it's a reasonable choice.

Important to mention too, that most of the reports that talk about differences between various groups of textile workers do not include people in the general population. That is they emphasize differences within the population of textile workers, but because they do not usually include people from, say communities where there are no textile workers, they cannot [172] find out whether there are not great differences between textile workers and others who have never been anywhere near a textile mill.

Apart from prevention of the acute responses on Mondays that have been studied most extensively, the standard is also needed to protect cotton textile workers against an insidious development of chronic lung disease over the years.

The development of chronic lung disease in cotton workers has, of course, been known for about two centuries. I might recall that the first description stems from

England in the 1820s and the 1830s. That exactly 100 years ago the term byssinosis was introduced in a French textbook in public health by Andre Ampust. He was talking about a chronic lung disease although the description was very skimpy at the time.

It is also, of course, well recognized and we describe an example of this 10 years ago, that many textile workers retire prematurely and many of them are obviously disabled before the age of 65. What has not been documented until recently is exactly how important, how many such disabled people and prematurely disabled people there are and it has been very difficult to organize such a study since by definition if one studies working population in mills, one sees those who are able to work and not those who have retired, for whatever reason that may be. And to get more information on the total group at risk, that is those who still work and those who no longer work, we [173] organized in 1973 a community survey, a community based survey where we traced cotton workers who had been employed in cotton mills at a certain defined period in the past, resulting in a population of cotton textile workers who had with few exceptions been employed in cotton textile mills for more than 20 years, an average duration of employment of some 35 years.

We compared the data in this group to data obtained with exactly the same methods in members of community population, at least one community rather close to the textile workers community but a community without significant number of textile workers and we also used data from two communities in Connecticut.

As has been mentioned this morning, these studies have only recently been completed. They have not yet been available. In fact, they are under consideration for publication right now but I am convinced that within the period that the record is open the definitive copy of this paper can be submitted after it has been accepted.

I would like to give my comments or some data that are based upon this study. Perhaps I might mention a few more details. It concerned total number of 675 male and female, white cotton textile workers. The number of blacks in our population was too small to be, we could not analyze that because there were fewer than 10 or so black people in the age group, 45 years and older.

Our control data consisted of a group of 356 males [174] and 662 women of the same age. It is especially important to stress that within the population of cotton workers we had a large group of women, 371, about two thirds of whom had never smoked in all their lives. And I will quote some data especially about this group of women who had never smoked because in studies of byssinosis smoking always comes up as a somewhat confusing factor and that is for a good reason.

The number, yes, we had a total number of 254 non smoking women among the textile workers and as an example, 25 percent gave a history of frequent wheezing, chest tightness. In the control populations, we had 381 such women and only seven percent had a similar degree of wheezing and chest tightness. This was a highly significant difference. The differences were of similar magnitude and all very highly significant for chronic cough as well, for chronic sputum production and for shortness of breath.

We also, of course, looked at the inference of smoking and we compared non-smokers to the smokers, textile workers as well as controls, and, if one does that with a suitable statistical analysis, smoking comes out as a significant variable. But the fact of exposure to textiles, to work in textile mills is a much more significant variable so it becomes immediately clear that if one looks at the significant variables within a population of textile workers then one will find and it has actually been found, that smoking is the next most important [175] variable.

But in comparing the population of textile workers with those who have never been in textile mills with the general population outside the mills, the variable of work in textile mills comes out as the most significant one.

With respect to shortness of breath, I might mention that we found no effective smoking habits on the prevalence of shortness of breath. We found that there the work in textile mills was the only significant variable.

Now, we of course, looked at various categories from textile workers in this population and compared the prevalence of symptoms among them and we found, somewhat to our surprise, that the prevalence both for males and for females, of chronic respiratory symptoms was not significantly different between card room workers, spinning room workers, yarn preparers and weavers. In all these categories, separate or combined, the difference of course, was very highly significant in comparison with the control population.

I might also mention that the prevalence of so-called Monday symptoms of byssinosis in this group and prevalence of other symptoms on return to work after a weekend or holiday, was not particularly high. The highest prevalence was in the male card room workers, 35 percent if one included all symptoms on return to work. It was lower in female card room workers, 18 percent and, similarly lower in the other categories.

[176] Now with respect to lung function, we also made a very careful assessment of lung function both in the control group and in the textile workers.

First of all, we studied approximately 3,000 healthy non-smokers, males and females, blacks and whites, in the control populations in the three communities where there were no textile workers included and on those 3,000 people we based our predicted values.

We analyzed these with respect to age, weight and height. Using that material as a base line then, we could then determine to which extent the cotton textile workers

as well as our community population as whole, that is including the smokers, the people who were at risk of other occupational risks that might exist in some of these communities but which were not cotton textile mills and we could, in this way, compare to which extent the general population in these Connecticut and South Carolina communities differed from a large group of healthy non-smokers and to which extent the specific cotton textile workers differ from the general population and from the healthy non-smokers.

Just to summarize these data, we found both among the males, both among the men and the women, a highly significant increase in lung function loss among the textile workers.

As an example, to quote again, the non-smoking women which are large in number, the forced FEV one in those women [177] was 234, non-smoke life time nonsmoking women, was .246 liters less than that in healthy non-smokers of comparable age, weight and height. And a similar figure for the general population was 0.05, highly significant difference.

This is true for all comparisons between textile workers and controls regardless of smoking habits.

If one looked at smoking textile workers, we found that the added decrement or function in them was just about the same as the added decrement among smokers in the general population so that the effect of textile work and smoking on lung function appeared to be rather simply additive and independent of one another.

Now it is important to mention that this lung function loss was determined in a group of people where the majority were no longer working in the cotton mills so that it is very unlikely that more than a minimum part of this loss could or was due to acute effects of dust exposure in the mill.

Moreover it was our policy to administrate an anti-an airway dynatal drug in all persons who were willing

to take that drug who had a low lung function of certain limits so we made it as sure as we could that we were, in effect, dealing with non-reversible lung function loss.

On the basis of this study and together with the data that have been given in the proposal that we published in the Federal Register we have made an estimate of the total number [178] of disabled people because first we saw a certain number of people in this survey, not a negligible number of people, whose lung function was so low that most specialists would have no difficulty in considering them as disabled people.

For instance, when we took an FEV one level of 1.2 liters as the criteria to indicate disabling lung function loss commonly associated with serious exercise limitation, then we found that in the age group 50 to 69 years, 12 out of the 208 male cotton workers were so disabled, that's 5.8 percent and a similar percentage in the control community was 2 percent. So it was three times higher among cotton worker populations.

We found disabling lung function loss among four men and 26 women who were life long non-smoking cotton textile workers and, of course, there were also smokers and exsmokers with equally severe lung function loss. It appears that the additive effects of textile dust exposure and smoking have mostly the affect to decrease the age at which textile workers become disabled because the disabled smokers were on the average, some five and a half years younger than the disabled non-smokers.

The extimate of the total number of disabled people who might have disabling function loss relating to the workers in the cotton textile industry represents, of course, an extrapolation but I don't think that it's far off and I don't think that our studies over estimate the disability. To the contrary, I think that we rather underestimate it because we found out that [179] a lot of these retired workers had moved away and, of course, we

couldn't see people who were not there. While we were very likely to trace most of the active workers which is, of course, the group biased in favor of the more healthy ones.

So, if anything, I think we have underestimated the prevalence of disabling lung function loss and not overestimated it but of course, still the estimate, of course, one should allow for a healthy margin of error because it does represent an extrapolation.

* * * * *

[244] [Dr. Kilburn:] Secondly, and Dr. Bouhuys emphasized this beautifully, I think, we have the coal miners fallacy. If you have a job that requires a fairly high level of physical activity, as textile work does, whether it is docking, or weaving, or particularly if it is carding or picking, only [245] workers who have a certain level, that is fairly high, of physical capacity, are found in work crews. Thus, if one doesn't study retired, or disabled retired people, one is lead down the primrose path in assuming no disease may be produced, or underestimating the true prevelance of the disease.

* * * * *

[310] [Dr. Weill:] I noticed, I think it was Dr. Kilburn or Dr. Bouhuys yesterday, that in a control mill, explained a low prevelence of Byssinosis of one or two percent as perhaps related to past exposure to cotton dust. I would suggest that a very possible explanation is that there is a certain amount of noise in the questionnaire responses which make it not unreasonable to have some positive responses in a non cotton dust exposed population. The particular mill with the highest prevelance of Byssinosis was a mill that had been studied on a number of occassions before, that is the workers have been studied previously, and they were pretty familiar with the questionnaire and it is possible that they were more aware that symptoms that they had, were in

fact, those symptoms being solicited. The less sophisticated population may not be that aware. It is one of the explanations, perhaps, that should be considered to explain our low prevelance of Byssinosis in the cotton seed process.

* * * * *

[317] In terms of the question of whether or not the biologic response variable that one looks for, what are we trying to prevent. We are trying to prevent bronchial constriction. I strongly favor the prevention of the demonstrated reduction in airflow as measured spirometricly or obtained through the questionnaire responses. Because, ultimately, preventing the bronchial constrictive effect, I think we will probably prevent the chronic disease.

You know there is nothing unique about repeated acute bronchial constriction leading to long term fixed airways obstruction. Chronic effects of Byssinosis are chronic effects that would be equally found had they been studied as well in other industries and in other situations where there has been asthma, and Byssinosis is, I think, really a form of occupational industrial asthma. Ultimately, repeated bronchial constriction leads to fixed airways obstruction. By what mechanism is a complicated subject as Kaye Kilburn mentioned last night.

* * * * *

[334] * * * It is very difficult to standardize and calibrate interviewers so that they are all asking questions in the same way, the same inflection, and so forth.

Our epidemiologists spend a lot of time with that. But still people are different when they ask questions and in interpersonal relationships. In addition to that, the level of education, awareness, sophistication of the interviewee differs markedly from industry to industry and from place to place.

Some of the studies we are doing, the exposed population in general are graduate engineers in a big chemical

installation. Well, their responses to a questionnaire might be somewhat different than a rather poorly educated and very often—I didn't mention this—illiterate population in a cotton seed oil mill, for instance.

The other important variable and no one likes to talk about it, but it is an important one I think; and that is the use of the questionnaire repeatedly and its value after it has been administered for some time in the past.

I think it was mentioned, actually. I think somebody talked about it yesterday as a virginal population, and the population changes when you study them again. Well, they do change. And the second, third, or fourth time, they may change markedly.

[335] I am not impugning motives. I am not suggesting that people are giving false answers. I am just suggesting that there are all sorts of influences that might very seriously affect the results. Now lung function, if it is done properly and all the calibration procedures, the methods of administering the tests are adhered to, I think, is less subject to some of these problems.

* * * * *

[483] [Mr. Held:] I would first like to re-emphasize the desirability of controlling exposures to cotton dusts by means of engineering methods. Respiratory protective devices have many limitations which make them undesirable if engineering controls are at all possible.

Among the limitations of respirators are A, fitting problems with persons with small faces, such as many women, with persons with facial hairs, such as beards or long sideburns, scars or growths which break the face piece to face seal, and with persons with pronounced wrinkling, a sunken nose bridge, deeply cleft chin, very narrow nose, a very wide or very narrow face, or very long or very short face; B, communication problems between workers wearing respirators. Any respirator will muffle voice communications to varying degrees. With many devices, the jaw movement used for speaking can break the face piece to face seal and cause inhalation of

contaminated air; and C, vision problems can be numerous. [484] Downward vision is obstructed with half or full face masks, thus increasing tripping or stumbling possibilities. The inability to look straight down can cause a serious injury. Full face respirators will restrict the wearer to tunnel vision. Persons who must wear perscription glasses must be fitted with special glasses kits for full face masks.

JUDGE FATH: I wonder if you could summarize your statement please?

* * * * *

[485] MR. HELD: Alright. Fine. D, fatigue and reduced efficiency, and E, some people, for reasons of health, would not be permitted to wear a respirator.

* * * * *

[500] MR. FREEMAN: You have testified as to your experience [501] with the workers at Los Alamos, I believe, and the wearing of respirators.

MR. HELD: Los Alamos.

MR. FREEMAN: And other places, the Univeristy of California?

MR. HELD: Yes.

MR. FREEMAN: Right. Are any of those workers required to wear respirators for their full time at work?

MR. HELD: We have had people, both places are primarily engaged in radiation research, and so, if there has been an emergency, a spill, or something, we have already had people 40 hours a week in a respirator, but not all year long, no.

MR. FREEMAN: I see. What is your impression of the ease with which workers handle the problem, or handled the wearing of a respirator for 40 hours a week?

MR. HELD: Well, as I mentioned in the statement, it is not an easy thing to do. We have had frequent work breaks in order to let them, instead of the usual one coffee break in the morning, one in the afternoon, we have

had to increase that frequency to a fifteen minute break every hour or two, and depending on the ambient temperatures under which they were working, and so on.

MR. FREEMAN: Would you have to increase it more frequently for higher elevated temperatures?

[502] MR. HELD: Oh yes.

* * * * *

[540] [Dr. LeSourd:] Engineering controls may be defined as methods designed to collect and remove dust from the air, either by capturing the dust at it's source or through general ventilation and air filtration. It may also include modifications of production equipment and procedures to reduce the dust emissions and substitution of materials to reduce or eliminate toxic components of emitted dust.

We began with the determination of with a feasibility of engineering controls as a means of achieving the desired exposure limits. In general, this is a matter of determining a combination of room ventilation and of local exhaust ventilation as could be applied to the processes involved in each of the industry sectors that were identified as dust sources.

All yarn mills and most other cotton processing establishments except gins, are air conditioned with the air recirculated and supplemented by a limited amount of make up air as needed. Although some filtration is built into any [541] air conditioning system, these systems have not, in the past, been designed to maintain very low dust levels where dust removal efficiency can be enhanced, by the installation of multi-stage filtration systems. But, where the dust sources are substantial, achievement of room dust levels in the range under consideration for this standard, requires the application of low exhaust ventilation as well.

* * * * *

[561] However, the results in this analysis only point out the relative difficulties among size classes of companies and between industry sectors.

Because of the severe data problems, that is the inability to estimate costs for specific companies only in relation to aggregated sales data, where available and the lack of detailed financial data for small companies, our analysis fails to identify specifically which plants will be more likely to close or what proportion of total production capacity will be eliminated due to compliance requirements.

In the course of the study, RTI alerted OSHA to some of the difficulties that the cotton textile industry might encounter in complying with the proposed standard, two factors in particular were identified, the development, production and installation of control equipment by the control industry and second, the ability of textile firms to finance the capital investment required.

Neither of these is completely intractable, given enough time. Estimates of the time required for the cotton [562] textile industry to come into compliance with the proposed standard cannot be made with certainty. A large number of firms are involved and each one will have special conditions constraining its action. Nevertheless, after consultation with textile firms and suppliers of control equipment and consideration of normal business practices and the experience of other industries, RTI suggested that compliance by the yarn producing sector with an exposure limit of 0.2 milligrams per cubic meter, it was estimated would take as much as eight or more years.

For other sectors of the cotton textile industry, RTI estimated that compliance at each exposure level could require two to three years more than for the yarn producers.

The primary basis for these estimates was the problems that the control industry may have in supplying the required equipment. Each installation will tend to be

custom designed for that plant and at best there will be considerable time required to complete and test the installation.

For some equipment, also, entirely new designs will be needed and such new technological applications will not be available immediately, even though the general methods to be used are known.

Financing will also be a problem for many firms. RTI was not able to estimate the extent of this problem since the detailed financial information for each firm is not available.

* * * * *

[594] MR. MOSS: Were you able to quantify the effect and, if so, would you tell us what damage, if any, you would expect the standard implemented to have on our balance of trade.

DR. LEE: No. Because in order to quantify I must have import demand elasticity and beside I could not find appropriate import demand elasticity estimate. That was one factor and another factor was, as I discussed it a few minutes ago, price was not only factor so if I combine those two reasons, one is I could not get appropriate import demand elasticity and I found out in literature survey that price is not only the factor of deterination of import. I could not quantify impact on import.

[595] MR. MOSS: Well how about exports of our textiles produced in the U.S.

DR. LEE: I told you I didn't investigate impact on export in this report. So I did not investigate it.

DR. LESOURD: May I clarify?

JUDGE FATH: Mr. Moss, the witness apparently doesn't have any information on the question of exports. He didn't investigate it and I think he's indicated why he didn't investigate it.

MR. MOSS: Well, now are we clear here that a few minutes ago we were talking about exports of raw cotton in the bale. Now we're talking about cotton textiles.

JUDGE FATH: It wasn't clear to me.

DR. LESOURD: Let me just make a general comment if I may. We did look at export and import problems. We did find that in addition to price, the domestic price of raw cotton or cotton products, there were a number of other factors affecting the international trade, both import and export.

As Dr. Lee has suggested, matters of exchange rate, change, matters of the quotas and tariff rates, the general governmental regulation of imports, agreements on imports, there were such factors affecting the market.

We deemed it inappropriate and probably ineffective to try to project future export flows on the basis of the projected change in price that we had developed in the face [596] of the unknown and frequently more dominant factors affecting both export and import flows. So we confined our analysis to a discussion of the foreign trade issues, the factors affecting it and we did not attempt to quantify the resultant changes and this I think is clearly demonstrated in our basic report in the pages cited by Dr. Lee.

MR. MOSS: Yes, I, on page c-52 I believe you cite the monetary changes since 1971 as examples of price changes that were large enough to affect the trade balance.

Of course, then, our question follows, can you tell us the magnitude of those monetary changes as compared with approximately 18 percent increase you expect the standard to cause in the price of cotton fabrics and yarn.

DR. LEE: We did not quantify in our report about the impact on balance of payment.

MR. MOSS: If the price increase due to compliance with the standard is greater than those monetary changes which have occurred since 1971, would you think that would affect the balance of trade in cotton textiles.

DR. LEE: That argument has little bit shaky ground because those factors are not independent ones. Those factors might be interdependent then we cannot make any kind of priority judgment unless we look at empirical data.

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[617] DR. LESOURD: We calculated the incremental cost from an assumed compliance with the 1.0 milligram per cubic meter.

DR. MERCHANT: Of total dust.

DR. LESOURD: Yeah.

DR. MERCHANT: And that was across the industry.

DR. LESOURD: All costs—

DR. MERCHANT: All costs.

DR. LESOURD—were presented as incremental, yes, in that sense.

DR. MERCHANT: Did you take into account data which I was presented. I'm not sure if you were here for Dr. Kilburn's presentation but it was a part of his package which showed that substantial proportions of the industry are, in fact, within compliance of what the proposed standards is, that is two tenths of a milligram, vertical elutriator dust.

DR. LESOURD: We didn't have data on the degree of compliance currently in the industry.

DR. MERCHANT: You did not seek to apply any of the data that had been collected in the industry to try to take this into account.

DR. LESOURD: I don't think, from my memory of what we had, that we felt that we had available data that indicated the degree of compliance for the industry.

There had been studies of specific mills. There had [618] been studies of dust levels in specific operations but I don't believe that we had available to us data which would indicate the percentage cards that were controlled to a particular level or similar data for any other process or industry sectors.

DR. MERCANT: So let me make sure that I understand this clearly. You assumed across the board for all processes that you costed that they were all at the compliance level of one milligram per cubic meter of cotton dust, total cotton dust, regardless of whether it was a cotton mill or synthetic cotton mill. Is this correct.

DR. LESOURD: Yes.

DR. MERCHANT: Or whether it's a yarn mill or weaving mill.

DR. LESOURD: Let me confer with Mr. Wright. Mr. Wright points out to me that what we were doing was costing so that we calculated a difference in cost for the levels of compliance. We really didn't make any assumption or determination of the number of plants that were in compliance nor did we assume that everyone was in compliance. We merely calculated an incremental cost to increase controls from 1.0 milligrams per cubic meter total dust to .5, .2 and .1 milligrams per cubic meter of elutriator dust which is an incremental calculation without any real knowledge of what the degree of compliance was.

DR. MERCHANT: But, if I understand what you're saying, [619] you're saying that across the board you started at one milligram regardless of the operation and costed what it would take to go from one milligram to five tenths, two tenths or one tenth. Is that correct.

DR. LESOURD: Yes. We calculated the incremental cost.

DR. MERCHANT: So is that, in fact, not an assumption that the industry is at one milligram?

DR. LESOURD: No, I think we were aware that the degree of control varied from plant to plant and we were, it was our understanding that we were to estimate the cost of this standard, costs attributable to this proposed standards would not include costs attributable to the achievement of previous regulations. Therefore, one is excluded from the other and we have an incremental cost.

DR. MERCHANT: Right. Now, let me put this question to you. If a portion of the industry is, in fact, currently at two tenths, is it reasonable to you that they should be included in this analysis. This is a hypothetical.

DR. LESOURD: I don't quite know how to answer that. If we had data that clearly indicated the amount of expenditures that had been undertaken to accomplish specific dust levels in specified portions of the industry, then we might want to look at this, but we didn't have such data so we didn't.

DR. MERCHANT: If you were provided with such data [620] that I think has been submitted from both OSHA witnesses and also in submissions from the industry would you be able to recalculate these sorts of estimates.

DR. LESOURD: I don't know without examining the data in detail and considering the procedures that would be necessary, I really couldn't answer that.

DR. MERCHANT: Do you think it would be reasonable to look at that data.

DR. LESOURD: I don't know what you mean by reasonable. Yes, out of my own curiosity I probably will look at the data that's submitted in this hearing but do you mean, I'm not sure what you mean beyond that.

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[646] DR. LESOURD: Let me answer this way, if I may. And I don't mean to be unresponsive. Only to say, that we don't claim that these costs are a precise—that our cost estimates are precise measure of the costs which would be necessary to achieve the control levels stipulated. They are estimates, approximations. They are based on average conditions, on general conditions. They are intended to give a reasonable reflection of the level cost involved. But, do not claim to be precise. Partly because there are a number of costs involved in which may vary from plant to plant, depending on what each plant has in place, the space that is has available, the

peculiar problems that may be related to installation of new equipment, within that plant, which would effect its cost.

This being the case, we have presented only [647] measures to indicate the magnitude of expected cost. Approximate level that may be expected and the costs, other estimates of costs may well differ, depending on more detailed knowledge of the exact equipment in place and the requirements on a mill by mill basis.

So that, we don't intend really to defend these costs as being precise and exactly what would be required.

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[813] [Dr. El Batawi:] So if I go back in retrospect and look at my earlier papers of the 60s, of the early 60s, I would then exclude grade half and call it dust reaction, I would call byssinosis only grade one and then I would say that the cotton dust mainly has three types of effects. The acute effect which could be irritation of upper respiratory tracts and the bronchi and that is the reaction to dust at the early stages, then the byssinosis which is the [814] typical tightness at the beginning of the week or following return from holidays and then the third type reaction or effect is the chronic obstructive lung disease with its different stages.

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[838] MR. GREENE: Could you explain why you think the people [839] worked there the longest had the higher grades of byssinosis.

DR. EL BATAWI: Well the explanation we gave is that the repeated insults on annual basis to the reserve capacity of the lungs eventually leads to damage of the respiratory tract.

MR. GREENE: You mean in the six months off these people did not toally recover.

DR. EL BATAWI: Well they could recover, definitely as soon as you remove them from exposure to dust, don't

get byssinosis. You only get byssinosis when you are exposed to it first day of the week but in the first year after six months of exposure he might come out with little derangement in the upper respiratory tract and keep coughing for two or three months afterwards. The second year a longer period of time, the third year more and so on until there comes a time when the condition is actually chronic bronchitis and leading to disability.

MR. GREENE: So then the six months off does not make a person "as good as new". Is the person exactly the same in terms of his lung, his pulmonary function or abilities after he's—

DR. EL BATAWI: Are you a doctor.

MR. GREENE: No, excuse me, I'm not.

DR. EL BATAWI: Well it is known in all occupational medicine if you have a certain degree of exposure and a biological [840] reaction to it you interrupt exposure, this biological reaction gradually disappears and then some regeneration occurs. If you repeat the insult again, the ability to combat that harmful agent is already lower down by the previous exposure and the duration of time to regenerate after interruption of exposure will be longer and there comes a time when during the season when they are not exposed to dust they still cough.

MR. GREENE: Maybe then what was confusing me was this term reversible. By reversible I just thought that means as a layman, that it would go away completely again. How would you define this word reversible in terms of this byssinosis.

DR. EL BATAWI: Reversible means, in the early detection of health impairment definition you mean.

MR. GREENE: Or any way.

DR. EL BATAWI: Health impairment, there is always an effect happening to any kind of exposure but that effect may not be harmful and in occupational exposure to different things, let's say the cotton or the flax

or whatever, the preliminary effects is a violent reaction by selia and mucuus membrane and so on. And then irritation to these. There can be other things like micro-organisms, doing something to the microfacts of the lung and so on. It can be other things like histomenic operation of the muscles and the muscles are secreting histomene and there is the effect of that. So at one stage of one, in the early stages, you have certain changes when you [841] suspend exposure they are reversed completely. The person becomes normal. But then if you repeat the exposure again, his ability to combat that is most probably less than when he was originally normal to begin with.

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[1000] DR. MERCHANT: Before I get started it may be useful to just review my professional background. I graduated from medical school at the University of Iowa in 1966, had training in internal medicine at the Cleveland Metropolitan Hospital from 1966 through '68, joined the Public Health Service in 1968, was assigned to the North Carolina State Board of Health, where I worked with John Lumsden in the Occupational Health Section.

It was at that time that we got involved in our studies in the cotton textile industry. In 1970 I took a fellowship in environmental and pulmonary medicine at Duke University and at the same time was a student in the Graduate School, School of Public Health, Department of Epidemiology, in Chapel Hill. I finished my clinical training [1001] in 1973 and in 1973 I was also awarded the Doctoral Degree in Epidemiology.

At that time I joined the faculty of the Department of Medicine, Department of Epidemiology at the University of North Carolina. I shortly thereafter was awarded a Trudeau Fellowship to study at the University of London for a year and I was associated with the Cardiothorasic Institute in the Bromton (?) Hospital in London from 1973 to 1974. At that time I returned to

the University of North Carolina for about a year at which time I took the position as the Director of the Appalachian Laboratory for Occupational Safety and Health in Morgantown.

This laboratory has as one of its primary responsibilities the function of doing research for NIOSH in the areas of occupational respiratory disease.

My comments on comments on cotton dust are based on my personal experience dating back to 1968 and in that time I have looked at textile workers and textile processes extensively in the United States, in Africa, in Great Britian, in Ireland. My comments were based upon interviews with approximately 3 to 4 thousand textile workers and the observations we made have been reviewed in the submissions that NIOSH has given for this hearing.

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[1002] DR. MERCHANT: This is some work that Schilling did and it is looking at the reliability of the diagnosis of byssinosis and in this particular study they looked at 183 cotton mill workers and two observers interviewed the subjects over a period of months. As you can see, the complete reproducability was 76 percent as to whether they had no evidence of byssinsosis, whether they had grade one which is chest tightness every Monday, or grade two, chest tightness on Monday and other workdays.

If you look at whether the workers was considered to have byssinosis or not, the agreement was better, it was 93 percent. I believe even after discussions they found that they could not agree on whether workers did have byssinosis or not in six of these 183 workers.

Schilling followed this up with some work looking [1003] at maximum voluntary ventilation, this is a slide that Kaye Kilburn showed. This shows the differences in the maximum voluntary ventilation which was calculated indirectly looking at FEV .75, to this was essentially looking at an FEV .75, very similar to FEV 1's that we will be talking about in a bit.

It shows the separation of the byssinosis grade 1, byssinosis grade 2, from the normal cotton workers and the health controls who did not work in cotton mills but who worked in a light engineering work where they had no substantial exposure to dust.

Notice the reflection at the bottom of the byssinosis grade 2, there were a number of workers who had been compensated for byssinosis who were dropped out, and their flow rates continued to go on down. So this is evidence of selection of affected workers out of the industry which is a very important phenomenon that is observed and has been observed repeatedly by nearly everybody who has looked at byssinosis in these vegetable and textile dusts.

When we started the process of doing our studies in 1968, we had a questionnaire which Peter Schrag had used in a previous study. We were not at all sure about the questionnaire diagnosis of byssinosis. We did use a questionnaire which I think Dr. Kilburn mentioned, talked about. We developed a byssinosis index. We did not use this to diagnose people as byssinotic or non-byssinotic, as has been suggested in some of [1004] the comments here at the hearing. We instead interviewed all of the workers and made a position diagnosis. We did have a byssinosis index in that particular study, and we made some observations.

This material was subsequently published in the *Annals of Internal Medicine*. It showed the effect of dust, it showed the effect of smoking, it suggested there was interaction between smoking and dust. This was a crude byssinosis index which was arbitrary and was not based upon any standard questions.

In 1969, I went to Great Britain and went to see Richard Schilling, and sat down and talked to him about the questionnaire. He gave me a copy of the questionnaire that had been used in Great Britain. It is a much more extensive questionnaire and was subsequently adopted by BOSH in their proposed standard.

We followed this questionnaire very closely. We used all of the questions for the diagnosis of byssinosis. We added one item to the chest tightness question and that concerned whether workers had chest tightness after a week or ten days away from the mill. Our experience in the earlier survey had convinced us in our clinical examination that this was an important question, and I would agree with those who comment on it that this is an important question and often workers will give you a very clear cut history of byssinosis after they come back from a holiday. Whereas, they may not [1005] otherwise. So this was a modification. But other than that, the questions used in the earlier studies in Great Britain, particularly those of Molyneaux and Tombinson were the same.

Using this questionnaire we wanted to test the reliability of it in our own hands and so we did this exercise with a number of us participating. We had two chest physicians, Dr. Kilburn and Dr. Harris, interviewing patients independently of the questionnaire which was given at a different time. And then we had a very abbreviated questionnaire which consisted of just a couple of questions having to do with chest tightness.

I do not want to confuse anybody by suggesting that we are making a diagnosis of byssinosis on the basis of pulmonary function data because the diagnosis of byssinosis can only be made by the characteristic symptomatology. This is a point that Dr. Taylor will comment on when I am finished.

We did find a substantial degree of agreement between the standard questionnaire that Schilling had provided us, the chest physicians who were interviewing patients independently using any questions and means that they felt they should. And then this very abbreviated questionnaire. I think you see the degree of correlation between these various methods.

We felt after that that the questionnaire was an instrument that we felt was reliable and reproducible, we

felt was particularly reproducible in those who had Monday chest tightness every Monday, the grade 1 and the grade 2. There is [1006] more variability in the grade 1 half workers because their symptoms tend to be intermittent. In our experience this is less reproducible and I think most people have found this.

We looked at the validity of this. We looked at flow rates over a week, and again this is a slide that Dr. Kilburn showed. It shows the different in physiological pattern between asymptomatic workers, those in this case who had byssinosis, grade ½, and those who had byssinosis grade 2, we had no byssinosis grade 1 subjects in this particular study.

This pattern has been studied by Gandidi, it has been studied by those who did the work, by Carey and Elwood in Ireland. Everybody shows a similar type of pattern. There appears to be a different pattern for different grades. The workers who have grade 2 have a very clear cut and prominent drops throughout the workweek; whereas those with grade 1 tend to level out in the middle of the work week.

Now the objectives of the study that we developed dose response data from was to look at byssinosis prevalence in all primary textile mill processes over the wide gradient of dust exposure. We realized at that time that we had no opportunity of doing a truly representative study of the entire textile industry.

We did have an opportunity to look at Burlington Mills in North Carolina. We were limited to North Carolina [1007] because the North Carolina State Board of Health was one of the principal supporters and participants in this study. Within that population we selected 8 mills out of 22 that we looked at. We were looking at a number of different processes. What are aim was was to get a wide gradient of dust exposures. We realized from the outset, and we made a conscious decision that this was not a representative sample of the entire industry.

We did not have the opportunity to do that. Even if we had done a representative sample of Burlington Mills in North Carolina, we had reason to thing that this was not representative of the cotton textile industry either.

We are interested beyond looking at byssinosis prevalence in different processes, in looking at dust levels, in looking at response over dust levels, and we were interested in identifying individual workmen, making recommendations for their management, and we were very interested in looking at determinants of respiratory disease.

This was really the thing that was the primary criteria for the selection of mills and for filling in the design matrix that had been developed by Dr. O'Fallen to look at risk factors and respiratory disease among cotton textile workers.

So there were several objectives. I think we met these objectives fairly well through the results we obtained.

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[1012] DR. MERCHANT: The other thing we looked at was pulmonary function. This is age and height adjusted, FEV 1, over a work shift. This is the change in FEV 1 in cc's. We are looking at the same categories by smoking status; those who never smoked, moderate-heavy smokers, former smokers. We see that the synthetic and wool workers there is really no consistent change up or down. Below 1/10 it is the same thing. At 1/10 to 2/10 we start seeing significant drops, particularly in those who were smokers, not in those who had never smoked. [1013] At 2/10 to 4/10 we see more consistent drop, and then we see bigger drops up above 5/10. So we are tending to see a lot of internal consistency between our histories of byssinosis, histories of bronchitis, and drops in flow rates by dust level and by smoking status.

(Slide)

DR. MERCHANT: Now this is a figure that Dr. Kilburn showed, and I think some questions have been raised about means and medians. I think it is worth putting up again. We made a very conscious decision to pick medians. We felt that this reduced the outliar effect which introduced a lot of variability. We did not know how much of this might have been spurious, how much of it was real. At any rate, we picked the median distribution.

You see here looking at byssinosis prevalence, all grades regressed against dust levels by the three measures of central tendency. You see the median and the geometric mean running very closely together. They are highly correlated, byssinosis prevalence is highly correlated with dust levels.

You see the mean distribution is shifted over to the right. It tends to cross down at about 2/10, between 1/10 and 2/10, so they appear to be quite close down below 2/10. One gets up to about 5/10. The prevalence would be expected to be lower with the mean dust level. This is something that I think has been raised in the past. This has not, I think, been adequately [1014] recognized that there are, particularly as you get higher dust levels, there would be, in our data at any rate, expected to be such changes in byssinosis prevalence if you are talking about the mean exposure or whether you are talking about the median exposure.

Down at lower levels it appears not to be an important factor.

(Slide)

DR. MERCHANT: Now these are dose response curves which shows the standard regression analyses on the top. This is group 3. These are all workers in the preparation and yarn areas in the cotton and blend mills. We are correlating byssinosis prevalence to median dust levels. Superimposed is the probe and analysis

which is done by Ken Bush, looking at this same data. It was observed that the model fits the data very well in all instances and given us a good testing. There was very little difference between what was predicted by the probe and what was actually observed at dust levels particularly below 5/10.

We felt the points out above 1 milligram did represent selection and we eliminated that from the linear regression. However, these were taken into account in the probe. So we looked at it both ways. I think there is good evidence that there is selection from high risk dust areas and I will show you some data on that in a minute. [1015] The median dust level correlation for slashing and weaving is different. This, we feel, is due to the introduction of sizing which is respirable in size. We saw in the three mills that we looked at a distinctly different dose response curve for the people working in slashing and weaving compared to those working in preparation and yarn areas.

Again, there is a striking linear association between the two. I would say that we looked at the differences between workers in the preparation yarn areas, we looked at the effect of whether it was a blend mill or primary cotton mill, and we did not observe any differences in those responses.

The vast majority of the exposures below 5/10 were observed in yarn areas of cotton mills.

(Slide)

DR. MERCHANT: Now this is looking at the same data. The top regression is looking at all grades again. We looked at just grade 1 and grade 2, which is the second curve, and then the bottom curve is just looking at grade 2. You see the linear associations are maintained after high degree in all instances and you see the effect of the different grades of byssinosis here still at 1/10. It is suggesting that one would observe, and in

fact we did observe, byssinosis at all grades, even down to the 1/10 and 2/10 level.

(Slide)

DR. MERCHANT: Now Frank Mackinson said something about [1016] wash cotton. We did a number of studies looking at wash and steam cotton. We looked at wash cottons three times; one bale of cotton was prepared commercially and was donated for the study, the other two bales were washed by Burlington Industries, these were thoroughly washed bales of cotton, but just water washed with a wetting agent. This was the only thing that was added. When these were run, we consistently saw no detriment in flow rates, in fact, they tended to go up somewhat but that was insignificant. We saw dust levels reduced from about .75, they were reduced down below 1/10. We had very little symtomatology. I think we had one worker who complained of a cough during these trials but very little symptomatology so we feel that washing cotton can effectively, if it is washed thoroughly, can effectively eliminate the biological effects, both the physiological effect and the symptomatology. Of course, this is highly correlated with reduction in respirable dust.

(Slide)

DR. MERCHANT: I wanted to show some other—I guess we have gotten a bit out of order—but I wanted to show some other response data that I reviewed and some of the material that we submitted. This is data from Molyneau and Barrie, which was presented at International Conference on Byssinosis at Alicante in 1968. They are looking at medium dust. This is dust that is collected with the horizontal elutriator with a [1017] 2 millimeter screen. They are taking everything that comes through the 2 millimeter screen. That is what they calling medium dust. The byssinosis prevalence was

obtained from a questionnaire which was very similar to ours. The same questionnaire that Schilling gave me.

The correlation here, 1 c, is relatively good. The ring spinners they excluded from this analysis. But I think there is reason. These ring spinners, I think, represent a group of 108. One of the points they make is the accumulation of lint on the 2 millimeter screen in linty areas can serve as a secondary filter. So I think the validity of the medium dust levels in areas where there is a lot of lint such as ring spinning is open to question. In fact, I have talked to Barrie about this very problem.

They are seeing byssinosis prevalence very similar to ours, even with differences in dust sampling techniques. They cannot be strictly compared but obviously the respirable dust, or the fine dust, or the dust that is inhaled into the lungs would be included in the fraction below 2 millimeters.

(Slide)

DR. MERCHANT: This is looking at byssinosis in speed frame tinters and people who work in the roving area. In this country again you see a very good relationship between byssinosis prevalence and medium dust. Again, the figures are not that different from the observations we made in this country, even [1018] with differences in dust sampling techniques and the methods used.

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[1019] DR. MERCHANT: Now question has been raised about previous exposure and the effect that it may have on the diagnosis of byssinosis or on the occurrence of byssinosis. In the model cardroom experiments we did, we identified a panel of reactors. These were 12 people, some had typical symptoms of byssinosis, others had only flow rate changes. At any rate, we studied these men extensively and we found that by

varying dust level we could affect the proportion with chest tightness. And if the respirable dust level got up to, as it did on one occasion, up above 1.2 to 1.3 milligrams per cubic meter—this was respirable dust collected by a large cyclone the areodynamic diameter of which was approximately 10 microns below. It was somewhat different that the vertical elutriator dust that we collected. But when we got up to that level, we found that nearly all of these men would become symptomatic.

Similarly, we reduced the dust levels, the symptoms would proportionately come down. One sees that this is a highly linear response that one observes. I show this slide just to show the raw cotton dust exposures. We were also looking at steamed cotton. In this we found that the dose response for steamed cotton appeared to be somewhat different but, as Frank mentioned, this was not borne out by intervention studies.

This observation, plus the next slide which we [1020] essentially showed the same thing, that flow rates were affected in this panel by changing the dust level.

(Slide)

DR. MERCHANT: This was the linear response to the same workers. It would increase or would decrease, depending upon the level of dust. This together with the observation in our study, the duration of cotton dust exposure was not a significant variable. It leads us to conclude that the prevalence of diagnosis or prevalence of byssinosis is related very largely to current dust levels, as are changes in flow rates.

(Slide)

DR. MERCHANT: Now this is a slide that I would just like to show you, showing some of the internal consistencies in dust sampling. This was part of the steaming intervention study that we did. And although we saw some reduction in the opening blending and picking,

which are the open bars on the left, over a number of different sampling periods that make a total of ten different times that we studied this particular mill, you see in the carding and in the areas of yarn processing, spinning, winding, and twisting, that the dust levels were very consistent except at the end where we saw some increase in dust levels which we feel may be responsible —or that the steaming may be responsible for these increases in the later dust levels put up but a high level of correlation. I think this has been observed by others who will testify at this hearing.

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[1025] DR. TAYLOR: Your Honor, I am Jeffrey Taylor. I am Associate Director of Appalachian Laboratory for Occupational Safety and Health. I was educated in England, in Manchester. I graduated from medical school in 1952. After doing clinical training, went into pathology for four years. I then moved to immunology and I have been an immunologist since that time.

During the 1960's and early 1970's I have been involved in studies into the mechanisms of byssinosis. As many of you will know, the literature on byssinosis is very extensive and is littered with the fallen hypothesis as to the causation of this disease.

There are two major difficulties in understanding the causation of byssinosis; one relates to the worker himself, and the other to the cotton dust. Whenever a group of individuals interested in byssinosis get together, one of the major bones of contention is what do we mean by this term. From the worker's viewpoint, it is a sensation of chest tightness, which comes on several hours after working in a dusty cotton environment. It tends to become worse during the working day. And in the evening he finds it difficult to undergo normal activities, he finds it difficult to walk rapidly home, and tends to do very little.

This may occur only on Mondays, or it may occur on Mondays and other days of the week. From the physiologists' viewpoint, it is a decrement in respiratory function which takes place sometime after exposure to dust. These two views of [1026] byssinosis, the worker and the physiologist, do not agree entirely.

In large surveys there will be approximately the same number of people who show symptoms as shown decrements in function, but they will not be entirely the same people. There will be an overlap in that many people with symptoms will show decrement of functions, but equally there will be people with symptoms with no decrements of functions, and there will be people with decrements of function with no symptoms.

Indeed, normal individuals who have never entered the textile industry at all, will often show decrements of function equally as great as individuals with byssinosis. This has caused considerable confusion.

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[1032] [Dr. Merchant:] Clearly no inference from our study can be drawn as to the prevalence of byssinosis in the entire U.S. textile industry, but no study has been done, either here or abroad, that could do that properly.

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[1038] MS. SIMMONS: Dr. Merchant, do you feel that it is [1039] possible through a rigid medical surveillance program, such as the one proposed, to identify all reactors at an early stage?

DR. MERCHANT: Well, I think that is a very difficult question. I gather you are talking about this question in the context of the U.S. textile industry doing this?

MS. SIMMONS: Yes.

DR. MERCHANT: I feel that reactors can be identified. I am not confident that everybody who is having Monday chest tightness or having drops in FEV that

they are the only people who are being affected by cotton dust. I think it is very possible that you may have people you would identify for a variety of reasons. I think one of the major problems in identifying people who are symptomatic is that workers will very often deny their symptoms, particularly if they are worried about their employment. People generally deny symptoms anyway. Patients deny symptoms. I think this is a big problem in this industry. And I think, as Dr. Taylor testified, we know that people who give very typical histories of byssinosis will not necessarily show physiological effects. So I do not think that one could rely 100% upon physiology.

Another point is we have heard the textile industry is fragmented, there are a number of small plants. The ability of all manufactures to implement a high quality medical surveillance program, I think, is a problem. I think some surveillance program is necessary and certainly we should attempt to do as [1040] good a job as possible, but I would be very reluctant to place a lot of reliance on medical surveillance. I think the maximum reliance should be placed upon the environmental control of dust.

MS. SIMMONS: Dr. Merchant, even considering all of the different processes within the textile industry and the different grades of cotton that are being processed within different mills or within one mill, do you find, both in your own data and in other data that you have reviewed, a similarity in the dose response found by yourself and other investigators?

DR. MERCHANT: Well, we found a high degree of correlation with the data that Molyneux and Barre have reported. I think there are a number of difficulties in comparing data because the dose response data that has been collected in Great Britian has all been collected with a different sampling method. So as I pointed out in the slides I showed, the comparisons cannot be exact.

I think the important thing is that in the major study that has been done, the prevalence levels of disease at low dust levels, fine dust levels, or respirable dust levels, depending on how they defined it, were not dissimilar to ours and were in an area of low dust levels.

There obviously are some differences. There is another study done by Fox which shows a different dose response relationship which disagrees with the study done and reported by Barre and Molyneux. But I think the data that we have [1041] selected largely agrees with the British data, and in fact we were somewhat surprised when we were done how closely they did agree. I think the proposed rules make the point that there are wide disparities between studies. I think it is remarkable once dust concentrations and different processes are taken into account, even with the different methods used, different countries, slight differences in questionnaire, how similar the prevalence levels are from country to country and process to process.

So I think there is a good degree of correlation between the investigations. There are certainly some individual differences.

MS. SIMMONS: Dr. Merchant, did you in your studies adjust for the past use of the medical questionnaire on your population?

DR. MERCHANT: In the population we looked at the workers had not been surveyed in the past. This, I think, may be an important factor. How important it is, I do not know. One of the critical things in our survey is that we pointed out to the workers that this was an independent study that was being done. We found that we had excellent cooperation from the workers, from Burlington Industries. We had a high degree of participation. We felt that the workers were forthright, generally, although we found several instances of denial. I think this is a phenomena which is relatively common in this [1042] situation as in all medicine. These people

had not been previously surveyed so this was not a factor in our study.

MS. SIMMONS: Did you take into account, or do you feel it is important to take into account, the present effect of past exposure under differing circumstances in studying a mill population?

DR. MERCHANT: Well, in a cross sectional study, this is one of the limitations of this study. One does not know, over time, exactly what the dust concentrations have been. It is one of the reasons the mills we picked, we picked to be mills where the process had been stable, where the machinery in place had been stable and had not been changed recently, that the population was relatively stable. So we felt we could minimize the major differences in dust level in the past.

In following some of these mills relatively closely, we find that the dust levels are relatively constant and the raw products that go in and the products that they are using, and the machinery and the exhaust ventilation systems are not changed in any major way. I think there will be testimony to that point later on. So I think the dust levels are essentially the same.

I would like to point out that in our study we did not find that duration of cotton dust exposure was a significant or important variable. I pointed out on a couple of other slides [1043] that we, by changing dust concentration, could effect the symptomatology and the changes in flow rate. So I feel that the dust level at the time the survey was done or within the few weeks or months before the survey are the important things in terms of determining byssinosis prevalence.

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[1136] MR. THOMPSON: Do you have an opinion as to how long it takes to develop the symptoms associated with those grades one half to two, historical byssinosis and specifically to reach grade two level.

DR. MERCHANT: Well, I think that's a highly variable depending, it's on the individual. We certainly observed people within four years of employment who would develop typical symptoms of byssinosis and others took longer to develop this but we observed a substantial proportion within four years developed and gave us typical histories of chest tightness on Monday.

MR. THOMPSON: Would a competent medical surveillance program identify such a person long before he reaches this level.

DR. MERCHANT: Before he reaches which level.

MR. THOMPSON: Level two.

DR. MERCHANT: Level two.

MR. THOMPSON: Yes sir.

DR. MERCHANT: What do you mean by that.

MR. THOMPSON: I think you know what I mean by competent [1137] medical surveillance program.

DR. MERCHANT: Well, I think it depends, grade two depends upon the worker giving the characteristic history. If the worker, for any reason, should deny that history which, as I testified earlier, is not an uncommon phenomenon and I think could happen more often when people who are not from outside organizations are asking the questions. Then I think it's possible that one could miss true grade two byssinotics with a medical program that is competent, is professional, well run and I think it's still very possible that these people would not be identified because they would refuse to divulge symptomology for whatever reason.

MR. THOMPSON: Do you agree that medical surveillance is a vital factor in identifying those people who may be reactors to cotton dust.

DR. MERCHANT: I think medical surveillance programs are important and should be an integral part of the standard but I feel that this is a secondary importance to dust control and, as I said earlier, I would not want to have to pay a lot of reliance, put a lot of

reliance on medical surveillance in terms of dealing with the problem of respiratory disease in the cotton industry. I'm just not sure how effectively it could be accomplished.

MR. THOMPSON: Do you recognize that there are some people who are more susceptible of getting byssinosis than others.

[1138] DR. MERCHANT: Indeed there are. I would agree with that.

MR. THOMPSON: Do you recognize and would you agree that some of those people can be identified at the very beginning stage of their employment.

DR. MERCHANT: Yes, I believe some of the people can be identified early on.

MR. THOMPSON: Would you agree that if a medical surveillance program is in effect that more of those people would be identified than if a medical surveillance program were not in effect.

DR. MERCHANT: Obviously, if one does not look you will not find these people.

MR. THOMPSON: You agree then don't you.

DR. MERCHANT: I would agree, yes.

MR. THOMPSON: Would you then agree that with a medical surveillance program that meets your description of competence as a medical doctor, that you would have a better opportunity of removing those persons who are susceptible of byssinosis early in the game than you would if you did not have such a program.

DR. MERCHANT: Well, I think identifying people and removing them are perhaps two quite different things. In regard to the recommendations made as a result of an examination and the reaction of the worker to that. I'm more confident that one could identify people that were having reaction to the dust than [1139] I am that you will be successful in relocating these people. This is again, in my opinion, for a variety of reasons.

MR. THOMPSON: I didn't understand you, sir.

DR. MERCHANT: I said I believe it would be, you're more likely to identify reactors or byssinotics through use of questionnaires and physiological tests than you are to successfully relocate those same people within the mill.

MR. THOMPSON: Why is that.

DR. MERCHANT: Well, I think there's a number of reasons. If you have a significant proportion of your people affected there may not be adequate jobs at low dust levels, say below two tenths of a milligram or below one tenth of a milligram where you could place these people.

There is reluctance very often among the employee himself to leave his job. I think clearly some guarantees as to wages and opportunities must be an integral part of any recommendation to relocate somebody and it has been the experience in coal mining where miners are allowed, under the Coal Mine Health and Safety Act of 1968, to be transferred, a very low proportion of these men actually exercise their transfer rights.

So this is a very real problem with surveillance systems. You can have a very competent highly motivated medical surveillance team. You can identify the workers and then you may find the workers are very reluctant to give up their jobs for whatever reasons. Very often they fear that they're not going [1140] to be paid as much. They will not have the same opportunities. Problems of seniority. All of these things come into it. The only experience that I know of in this regard in this country has been in the coal mines where we find that fewer than 10 percent of these men will actually transfer even though they're given the right to transfer to low dust areas by law.

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[1325] MR. FRUMIN: Okay. On the top of page 17, you make the statement, "NIOSH does not recommend

continual respirator use. This is touching on the same subject.

DR. BAIER: It's an extension really of what I was just talking about.

MR. FRUMIN: When you say continual,—

DR. BAIER: Up to 10 hours a day for roughly a 40 hour week for a lifetime.

MR. FRUMIN: For a lifetime?

DR. BAIER: That's continual. What we're saying is you wear it until the control, the positive engineering control has been instituted and installed and, in fact, in practice.

MR. FRUMIN: Okay. Do you have any experience with [1326] respiratory protection programs requiring the wearing of respirators for a full shift.

DR. BAIER: Unfortunately, I do, yes.

MR. FRUMIN: Could you make an evaluation of these programs as distinct from those which do not require full shift wearing.

DR. BAIER: All I could say is wear one for a day. That's about the best way you can change your mind about how effective and how well these things are received and actually applied by the workers.

MR. FRUMIN: We intend to do that at a more appropriate time. Go ahead.

DR. BAIER: Oh. Okay. I wasn't aware of that. Actually what we're saying is that there are times that a respirator has its place. Unfortunately, that's been taken to mean in lieu of everything else, let's pass out respirators. Bob works for these things every day and he probably did discuss problems with fit, problems with breathing resistances.

One of the fundamental problems is that most times a worker accepts a respirator because he's having problems breathing. At least, that again has been experienced. And at that time the resistance is maybe too much and again, you wear the respirator around your neck or on a nail.

Aside from the fit, ethnic differences in face structure, these types of things, universality of the fit, leakage, people [1327] with bears, people with scars, I mean the respirator is just no good for. These types of things. Bob, if you want to go a little further. Or maybe you did.

MR. SCHUTZ: I want to add one more thing. I think the question was our experience with continual respirator use. My experience has been that they are only accepted for continual use in areas where the non-wearing of the device produces immediate reaction.

DR. BAIER: Yeah.

MR. SCHUTZ: Or immediate hazard to the wearer or the non-wearer as the case may be. In this case, this seems apparent there is no immediate reaction unless the man is badly disabled to begin with.

DR. BAIER: Yeah.

MR. FRUMIN: Mr. Schutz, you talked about, you mentioned the immediacy of the hazard here and it is a short term phenomena perhaps. Have you any experience with a respiratory protection program requiring full shift wearing of a respirator for a period of years at a time.

MR. SCHUTZ: Not years at a time, no.

MR. FRUMIN: You have no experience with any such program.

MR. SCHUTZ: No.

MR. FRUMIN: Are you aware of any such program.

MR. SCHUTZ: I imagine they exist but I have no first hand knowledge of any such program.

[1328] MR. FRUMIN: What would be the longest requirement of any respiratory protection that you would have knowledge of.

MR. SCHUTZ: I've known situations where it may be as much as two weeks, emergency repairs eight hours a day in highly toxic atmospheres such as nuclear industry. Gas manufacturing plants.

MR. FRUMIN: Have these programs met with uniform success or are you aware of any problems in the administration of such programs.

JUDGE FATH: I wonder if we can't take additional notice of the fact that a worker will resist and decline the use of a respirator because it's uncomfortable, doesn't fit his face and really doesn't do the job. Can't we accept that.

MR. FRUMIN: Well, if all parties in this hearing would stipulate to that to the primacy of that notion, we'd be more than happy.

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[1447] MS. SIMMONS: Since most investigators have shown that one can find respiratory symptoms in the absence of decrement pulmonary function and the reverse, would it be your opinion as a regulatory matter, a medical surveillance program designed to protect at the earliest possible time reactors should include both of these methods of control.

DR. MORGAN: Symptoms and decrement.

MS. SIMMONS: Should include both the questionnaire and pulmonary function testing.

DR. MORGAN: Yes. With the provisos that I mentioned yesterday and with the thought of a reducing grade 2 byssinosis rather than grade half. I think grade half byssinosis is a pretty nebulous entity and its importance is far from certain.

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[1514] [Dr. Harley:] Grade ½ byssinosis appears to me to have been useful in a lot of the epidemiologic studies which have been done. Most of those which have been done on byssinosis have been epidemiologic. However, I don't think it is a very useful tool in applying standards for a medical surveillance program. It is something that a physician who is examining such records can use in that he can look at people who have so-called grade ½

byssinosis a little more carefully than someone else. But that is about [1515] as far as its usefulness goes. It is nebulous entity, it is not a disease.

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[1604] Byssinosis itself, grades one half, one and two, in my opinion, really don't constitute much of a disease. It is a symptom that indicates that something serious might happen.

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[1779] MS. SIMMONS: In your opinion as a physician, is someone with Monday morning chest tightness a person who is sick or ill?

DR. MARTIN: No. Do you want me to make it categorical?

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[1881] DR. MERCHANT: My name is Dr. Merchant, from NIOSH. Dr. Imbus, in regard to medical surveillance, I believe in your statement, in your oral testimony, you spoke at some length of Burlington Industries' experience with medical surveillance?

DR. IMBUS: Doctor, I am not sure if I can—Repeat what you said; the last sentence. Burlington Industries' experience with medical surveillance?

DR. MERCHANT: Experience with medical surveillance?

DR. IMBUS: Okay.

DR. MERCHANT: Now, I believe you indicate that in order for a medical surveillance program to be effective, you must also have adequate environmental controls.

DR. IMBUS: Yes; I believe that engineering controls are a very important aspect of that.

DR. MERCHANT: Okay. Now, what proportion of workers do you feel a medical surveillance program could handle, in your experience, in terms of transferring people, reassigning people, things of that sort?

DR. IMBUS: Well, in my experience I don't think it could be a very high percentage. Certainly somewhere less [1882] than 10 percent, at any rate.

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DR. MERCHANT: Okay; fine. Now, what factors would influence you, or would you recommend the Department of Labor adopt, for providing guidance for transfer of employees who are effected? What parameters in your mind are important?

DR. IMBUS: Well, as I mentioned the other day, I am against any automatic transfer triggered by any specific [1883] finding per se. I believe that people who are reacting either in terms of subjective symptoms or a decrement of FEV_1 should be watched very carefully. I think that individuals who show evidence of developing chronic obstructive lung disease should be evaluated by a specialist and I think this decision of transfer really should be made by a physician after some careful evaluation of all of the factors involved in the thing.

DR. MERCHANT: Now, do you think that physician should be the corporate physician, or should this be an independent physician?

DR. IMBUS: Well, here again, I don't know that I can recommend to the Department of Labor what physician it should be. I do know that in our own situation, that we have referred these people out to independent physicians to let them make an evaluation.

Now, we also have input into it, but we like generally to receive their recommendations on the thing.

DR. MERCHANT: And ultimately, who in Burlington Industries is it who recommends transfers? Is it you, or is it somebody else?

DR. IMBUS: It would be myself or my assistant, the assistant medical director, based upon the findings of the specialist.

DR. MERCHANT: Do you consider absolute level of [1884] FEV_1 before exposure in your evaluation?

DR. IMBUS: Yes. As a matter of fact, the absolute level of FEV_1 before exposure is one of the things that can trigger a special evaluation.

DR. MERCHANT: All right.

DR. IMBUS: Yes; we consider that a very important thing.

DR. MERCHANT: And is there a level that you use as a guideline?

DR. IMBUS: As a guideline for a comprehensive evaluation, we use an FEV_1 of 60 percent of predicted; but that can be more or less depending on—This is, as I say, a guideline. We have found a considerable number of people with FEV_1 less than 60, especially the older, slim females, that we did have a lot of them evaluated and found them to be essentially normal. So we don't always; but generally, that is it.

Also, an individual who is having trouble, who is complaining of substantial tightness in the chest, or reacting substantially. These are other guidelines.

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[1896] DR. MERCHANT: Now, also, in your comment on Table 3, it says, "Even though dust levels here do not look inordinately high, it is obvious that further action needs to be taken to lower them, and medical surveillance is strictly an interim measure."

So in this particular instance where you are having dust levels of .4 to .5, I gather you feel that there is a need to lower them?

DR. IMBUS: We did, in this area, and I will tell you the outcome here. The carding area, which was very high, has subsequently been reduced from 1.92 milligrams to .4 milligrams and drawing and roving have decreased, have decreased—Drawing has decreased; and roving has decreased considerably, yes.

DR. MERCHANT: To what levels?

[1897] DR. IMBUS: Presently, the drawing is .35 and the roving is .06.

DR. MERCHANT: .06 for roving?

DR. IMBUS: Right. Right.

DR. MERCHANT: And what has happened to byssinosis prevalence and decrement in function? Do you have those figures?

DR. IMBUS: Byssinosis prevalence has dropped; the symptoms, symptomatic byssinosis, has dropped to 10 percent. There are 10 percent of the employees—I am talking about the overall card room area, now, and it is not a fair comparison. I would have to go back and break it out.—But of 49 people in the card room, it has dropped, the number of people with FEV_1 decrements, has dropped to 10 percent. So these figures are not exactly comparable.

DR. MERCHANT: Okay. And you say the decrement; and what about the prevalence?

DR. IMBUS: The prevalence of symptoms of byssinosis is 10 percent.

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[1904] DR. MERCHANT: Now, Dr. Morgan told us that these cotton mills were not unrepresentative of the industry. Do you agree with that?

[1905] (Conversation off the record.)

DR. IMBUS: I think that they might not be unrepresentative of many of the blend mills in the industry. I certainly think there are quite a number of all-cotton mills which have much higher dust levels.

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DR. MERCHANT: Now, in the figures that were provided by Dr. Morgan in regard to dust level, which I gather were done at the time of the survey; they represent the [1906] conditions at the time of the survey?

DR. IMBUS: Yes. We feel that they were; right.

DR. MERCHANT: We have calculated for Brighton a mean, and this is for carding only, of .3, and a median of .25, which is relatively close to the proposed standard.

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[1907] DR. MERCHANT: Now, according to the figures we have been given, there would be some 40-odd people exposed at .5, and combining the two cotton mills, some 90-plus percent of [1908] the people in the survey would be exposed at .3 or .2 or even below .2. Is that not correct?

DR. IMBUS: Well, I don't know. How did you arrive at those figures—

DR. MERCHANT: Based upon the figures given to us.

DR. IMBUS: —because I don't have the figures with me.

DR. MERCHANT: These were based upon the figures that were given to us.

DR. IMBUS: Oh, you are talking about—In other words, what you did was you coordinated Dr. Morgan's figures with these dust levels; is that right?

DR. MERCHANT: Correct.

DR. IMBUS: I have not calculated, Dr. Merchant. I just would have to go back and look.

DR. MERCHANT: Okay. Is it not true that the only group in these two cotton mills that were exposed at .5 or above would be the carders at the Clinchfield plant?

DR. IMBUS: Well, I believe you see at the Clinchfield plant the opening is above .5; and that is the only other group I see. As the Brighton plant, we have the opening areas and one of the picking areas; and carding number 3, here, is above .5.

DR. MERCHANT: Now, Dr. Morgan, despite the [1909] relatively low dust levels, that the vast majority of these subjects, employees, were exposed at, he found what he considered to be probable or possible byssinotics by pulmonary function testing in 11 percent in both plants, based on decrements in function.

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[2022] MR. GAWLAK: Okay. fine. I would like to now refer to exhibit 3. That is a letter to Grover N.

On page 4 of that exhibit you discuss the comparison of total dust to verticle elutriated dust. Now you mention that the fraction varies from process to process, is that correct?

DR. NEEFUS: Not only does it change from process [2023] to process but I have found out recently since I have been looking at the data a little more closely that the better collection of dust, the better capture of dust the closer the respirable dust is becoming to the total dust so it means that we are getting excellent lint collection. At least a lot better than we had so you really can only rely on any particular ratio between the total dust and the respirable dust. I don't want this to be misleading but our total dust sample is a little bit different than anyone else's. It is something John Lumpston and I dreamed up to try to have it reflect some meaning. In our discussions we tried to make it equivalent to the old 8 by 10 high vault total dust sampler. And so I believe that I have described that total dust sample in exhibit number one. So this is a reflection of that total dust sample to the vertical elutriator. I don't want you to be mislead that it is the OSHA type.

MR. GAWLAK: Okay, I see you don't want it to be misleading so I see we can't use the typical or the comparative factions that have been mentioned then? in this statement.

DR. NEEFUS: As you notice there I say the high otal. Because I want to make sure that you understand that it was not the OSHA total dust level.

MR. GAWLAK: I see, but in a general sense, in linty area such as the spinning and roving you will have a smaller per centage of vertical elutriated dust as total dust?

[2024] DR. NEEFUS: I didn't hear that, could you repeat that, I apologize.

MR. GAWLAK: Certainly. In a general sense, in linty air, such as spinning and roving you will have a

smaller per centage of vertical elutriated dust as total dust than you would have in a less linty area?

DR. NEEFUS: I don't know if that has any meaning at all. I don't think that you can rely on a ratio between total and respirable. There certainly has not been enough work done to make any kind of correlation between the two. The total dust sample is a very erratic sample. The respirable dust sample is not and, I have a feeling, is why NIOSH recommended to OSHA that we go to a respirable sample rather than a total sample. Because the total is unreliable and so why make a ratio between an unreliable and a reliable dust level.

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[2094] [Ms. Norton:] I once dreamed of being a nurse, that was a hope, but I am a mill person so I went to work in the mill. I didn't know that that dust in the mill would one day give me a disease like brown lung. Nobody in the mill ever tested my breathing. There was never any kind of education about cotton dust being dangerous. We got x-rays in 1947 for T.B. but that was all.

When they started speeding the looms up the dust got finer and more and more people started leaving the mill with breathing problems. My mother had to leave the mill in the early fifties. Before she left, her breathing got so short she just couldn't hold out to work. My step-father left the mill on account of breathing problems. He had coughing spells til he couldn't breath, like a child's whooping cough. Both my sisters who work in the mill have breathing problems. My husband had to give up his job when he was only fifty-four years old because of the breathing problem.

The first time I heard anything about cotton dust causing lung problems was when I received a card from the brown lung association. There was a number on the card so I called it and I talked with a man for awhile. He said I might have byssinosis. That was in 1976 and

it was the first time I had ever heard of brown lung. Now I go to a clinic because I can't afford a doctor. I had to retire at age [2095] fifty with a breathing problem that has since been diagnosed as byssinosis caused by breathing cotton dust. I never smoked a day in my life. For twenty-four years I worked in the weaving plant and now that the dust has made me sick I have no job, no medical insurance, no pension. My husband worked thirty-six years in the mill and he got no pension. If you think you can trust the mills to clean up without a strong standard that is strongly enforced that you have to think again. The company has done nothing in the past to help the people and they will have to prove to me that they are sincere. They treat people as if they were nothing, not even as important as their machinery.

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[2096] MS. MCCOY: My name is Odesine McCoy and I am from Spartanburg, South Carolina. I have worked in the mill for thirty-nine years, since I was fifteen years old. I worked in the mill because I never expected to do anything else. I always just expected to work in the mill all my life, my mother and my father worked in the mill, as did my brothers and my sisters. I lived all my life in the mill village. I retired in 1976 because of shortness of breath. I suppose I had a breathing problem since 1973. I just kept on getting sick and began losing time at the mill. Every time that I go into the mill I get deathly sick, choking and vomiting losing my breath. It would blow down all that lint and cotton and I have clothes right here where I have wore and they have been washed several times and I would like for you all to see them. That will not come out in washing.

I am only fifty-seven years old and I am retired and I can't even get to go to church because of my breathing. I get short of breath just walking around the house or dressing of sometimes just watching T.V. I cough all the time.

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[2106] MR. WALTER JONES: My name is Walter Jones and this is the testimony of Mr. Louis Harrell, who was too sick to come.

TAPE RECORDING: My name is Louis Harrell and I have been in the cotton industry for 30-some years. In the [2107] last 13 years I have been having trouble breathing and been horrible. However that is where my work is and the last four I have allotted to—and I seem to be getting worse and worse in my breathing. I think they should give me a job where there is at least not so much dust. And they said they would lift for me one—well they admit to that five, six, ten months and then I got a slip from my doctor in Duke saying I had to get out of the dust if I were to survive. I gave that to them and that seemed not to make any difference. They just didn't come across with anything so I had to quit because I couldn't lay down and rest without oxygen in the night and my doctor told me I would have to get out of there and I walked across to the mill. I couldn't even breathe, I had to get out of the door so I could breathe and he told me not to go back in there under any circumstances. So that is how I come to leave.

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[2132] [Mr. Sandlin:] And I have some masks here—different kinds, and I will put one on if you don't mind. This is what you're supposed to breathe through for eight hours. I can't breathe through one eight minutes. I got where I could not wear one at all. For even this time. And this is the glasses to keep the dust out of [2133] your eyes. You are supposed to work eight hours in this.

JUDGE FATH: I want the record to show that the witness has demonstrated the use of a respirator, is that what you call that?

MR. SANDLIN: Well, see, you can't. I can't breathe in one, they're hot, they don't keep out all the dust, they bother you about your vision—looking sideways from the corner of your eye, or even sometimes where

you're going, and they also—I don't wear glass but a lot of people do, and they fog them up quick, and they can't see. And they're just a nuisance.

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[2143] MR. HASSELL: During the past two years it has been my experience to represent persons in compensation proceedings. My clients were employed by the J. P. Stevens Company in Roanoke Rapids, North Carolina, and Burlington Industries in Erwin, North Carolina. In connection with handling their compensation claims, it has been my responsibility to prepare their cases and to try to collect all the medical information that I could. In order to present their cases to the North [2144] Carolina Industrial Commission. And in so doing, I have inquired of the mills as to what sort of medical information was maintained with regard to pulmonary function studies performed on employees and other aspects of medical surveillance program that you have heard testimony about during the course of these hearings.

Among other things, I have learned from my clients, upon receipt of medical reports that were prepared by physicians to whom they were referred by the mills, that in some cases, their lung function was described as being "severely impaired" and in some cases the medical reports requested that they be transferred, and in some cases the medical reports requested that they not be permitted to work in dusty areas again.

The point that I wish to make is that in several of these cases, my clients informed me that they were NEVER informed of the results of the results of their breathing tests, and they were never shown copies of the medical reports that were prepared. And at least one case that I can recall to mind—one particular man continued to work in the mill for two years after a medical report stated that he should not work in a dusty area again. I asked him about the report, and he reported

to me that he had never seen it, never been furnished a copy of it.

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[2145] I should cite the example of another client who worked in the mills for a number of years and who recently retired at a relatively early age, before 50 years old. And during the time that she was employed by the mill from 1970 until 1975, pulmonary function studies were performed, breathing tests were given to this person. But she was not informed of the results of those tests, and once we were able to obtain those records in connection with her [2146] compensation case, we learned that during each year that she was employed there was a serious detriment in her lung function, and she was never informed.

She was employed by the Burlington Company in Erwin, North Carolina. Which maintains that it has a medical surveillance program designed to inform their employees of their health condition with respect to breathing.

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[2147] I would just close by saying it has not been my experience in reviewing cases—medical cases of persons who are seeking compensation—that they have been adequately informed of the results of their breathing tests, and in some cases they have not been provided copies of the reports prepared by specialists.

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[2148] [Mr. Baldwin:] And I also was talking about letting the mill company run their own medical programs, measuring their own dust, running their own educational programs for employees about the dust. I don't think that's going to work anyway. —mill working will be—and in my story I will show what they have done [2149] in the past.

When I was working in textiles, the Company never said anything about cotton dust being harmful. And

even if they had, there wasn't much a person could do about it. Working in textiles was all I knew. We all knew that we had to work until they carried us out or you come out on your own. When I went to work in textiles, there was nothing in the world except cotton mills and farming.

I have been bothered by this chest trouble and I had it six or seven years before I quit working in the mill. The doctor who is the company doctor never called my lung problem nothing—he never said what it was, and now he is our main doctor, not necessarily because he is a mill doctor. I don't guess he was at the time he came to (?), but he certainly is one of them now. That's because he got most of his business from the mills. He used to come to an office there and—him and a nurse with him, and if you got hurt or anything that you needed to be—call for a doctor, you could see him on Thursday, because they wanted you to see him on Thursday. The boss didn't give you nothing but hard times. When you weren't able to run your job they just pitched you out and got somebody else.

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[2150] I have been diagnosed as total disability with brown lung. * * *

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[2152] MRS. SANDERS: My name is Reber Sanders. I went to work in the mill—the cotton mills—when I was 14 years old. And I worked a little more than 40 years in the cotton mills and (?)—the mill to clean up the dust—I want to tell you about it—how it costs me to have this disease. My breathing problem started about three years after I started working in the mill. I broke out all over from being in the dust and had to cover my nose with my hand all the time that I was breathing. They got me out of the mill once for nine months, and I felt like I was 16 years old—just as soon as I went

back in the mill the same thing came back on me, so the doctors told me I just had to let it go—that I couldn't stand it and I couldn't be alive for three weeks if I didn't get out of the mill. The Company told me they couldn't work me because I had insurance in the mill and I was in the hospital every [2153] two months and said I was costing them more than I was doing, so they let me go on account of being too sick to work regular. I didn't get one dime from them—not even insurance.

Medicare paid some of the medicine bills in the last 13 years, but not much. We paid about $30 a month just for medicine, and sometimes $100 for doctor bills. We had to sell our house because we couldn't afford to make payments—the cost of it and keeping it up. My breathing problem is also caused by heart problems. Last summer I had to go—I had a heart attack when I got to the hospital—they asked me what caused me to breathe so hard. They took an X-ray of me and found that I had—that my lungs nearly collapsed, and that had made me have that heart attack—breathing so hard it made my heart weak.

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[2154] I go to bed at night and that stuff just foams in my throat and it just comes out in big rolls. I have to take paper towels to bed to get it out. * * *

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[2187] [Mr. Graves:] They never told me to wear a mask or anything. They just had us wear safety glasses or goggles. Up to 1974 when I came out I never saw a mask at the mill. The dust put me out of work eleven years before my time. About 1965 I started getting short of breath and got to coughing all the time. I kept on working and it kept on getting worse. The last few [2188] years I worked I missed a lot of work. I was in and out of the hospital so many times I can't even remember just how many times. My doctor kept trying

different medicines and he finally said he had given me everything he knew to give me. The only thing he knew was for to get a transfer to another part of the mill. But the mill kept saying there are not any jobs to transfer you to. Even though they knew I was bad off. They said one time if you are unable to run your job we will have to replace you. My doctor said that I should get out altogether. That it would shorten my life every day that I was in there.

But I knew that I had to go to work. I had a wife and three children at home to support. I just went back and kept trying and trying. I finally collapsed on my job and and never went back. I got my disability at age fifty-four, not able to work anymore and support my family.

My point in telling my story is this, the company never educated us about the effect of dust even when they knew. I dont' think they will do it right even now. When they started the breathing tests they never told us what it was for and we never knew. The company let me work overtime every weekend cleaning up that cotton dust but they never told me it was bad for my lungs nor even gave me a mask to wear. They wouldn't even transfer me out of the dust where my family doctor wanted it. * * *

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[2376] [Mr. Hocutt:] The capture system is the real problem or more specifically, it is the difficultly of applying known dust capture technology to the processes of spinning, yarn preparation, and weaving. The filter requirements in those areas are no more difficult than in opening or card rooms; as a matter of fact, it will be cheaper per CFM because there is less quantity of dust.

When we cannot apply dust capture devices directly to the point of dust generation, as we cannot in spinning, yarn preparation, and weaving, we can only make up the

deficiency by using massive, wasteful, and expensive air quantities.

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[2377] The ring-spinning and yarn preparation machines that we have described are the most modern. And I don't claim to be any expert on open-end spinning, but I am told by people who are that it represents less than 4 percent of the production in the U.S. now; and none of the experts that I know expect it to ever replace more than 30 percent of the ring spinning, because of the difference in the characteristics of the yarn, which is a basic difference.

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[2388] MR. GAWLAK: I see. So you are just maintaining your present statement that we are not going to advance much in the next seven years in these processes we are discussing.

MR. HOCUTT: Or, I can put it another way. I think the only way that it could be effected would be in totally new technology, which obseletes and eliminates need for the textile processes now in use.

MR. GAWLAK: I see. But you are not talking about —You don't foresee any new dust control technology.

MR. HOCUTT: No. No; this is a very old art. The [2389] first movement of air for cleaning of the air was with the cavemen. They dug a tunnel from the back of the cave to the surface and induced a draft so that they could build a fire in the cave and the draft came in through this opening and it went out that opening, and that is the way they cleaned the air.

I know that there isn't very much new going on because we find it very difficult to get a patent on anything. Now we get patents on the nuts and bolts; but talk to lawyers and find out how many landmark patents there have been in ventilation and lint and dust control systems over the past 10 or 20 years. It is old, old art.

MR. GAWLAK: Okay, Mr. Nocutt. Let me move on a bit. You speak of hypothetical dust control systems in the processes past roving. Have you tried, has Pneumafil tried, any prototypes of the systems you mentioned?

MR. HOCUTT: Some, yes. We have buried a great deal of money we would like to have back in that kind of research.

(Laughter.)

MR. HOCUTT: You don't do that very long, see, before you have to stop and work on something that is practical.

MR. GAWLAK: Well, for instance, have you tried one of these systems for, let's say, one of these systems where you would require a barrier that you showed on the screen [2390] and would push the air through the floor. Have you tried any of those systems?

MR. HOCUTT: Well, I am disappointed. I thought I had shown that it is impractical to do that on a ring-spinning frame, because of the requirement for the overhead-traveling blower to blow on the roller beam and the drafting system and on the ring railer.

MR. GAWLAK: Right, sir. I understood that; but you didn't quite make it clear why you would need the traveling blower if you had massive air blowing through all of those devices.

MR. HOCUTT: Now you are getting into the difference between blowing and suction. There is a vast difference. Let's see.

I can set a candle on the edge of the table, and blow it out, but I can't suck it out.

(Laughter.)

MR. HOCUTT: On a more technical basis, the pressure on a suction orifice, when it is equal to the diameter of the orifice, when the pressure is measured at a point equal to the diameter of the suction orifice away from

the orifice, the pressure has dropped to 10 percent of the pressure in the orifice. Now, the carry on air-conditioning ducts, whenever you are blowing, is about 30 times the diameter of the duct. And so the answer to your question is that you can't [2391] suck the fly off the ring rail. You can blow it off, but you can't suck it off, see. You can suck it off the roller beam and away from the drafting system. You cannot do it with suction, but you can blow it off, see.

MR. GAWLAK: Okay. In general, then, you have tried many of the systems that you have addressed hypothetically, then, in your—

MR. HOCUTT: We have addressed all of these problems at one time or another, or we know what somebody did in Japan, or what somebody did in Germany, or what somebody did in England. And I have a flow of paper that covers me up; I can't read it all, of that kind of stuff, see, so—

MR. GAWLAK: Okay.

MR. HOCUTT: I don't believe anybody here could mention anything that hasn't already been tried and evaluated.

MR. GAWLAK: Okay. Let me—

MR. HOCUTT: I have a $3,000 machine in my lab that was built to move from loom to loom, and clean a loom; and it was a $3,000 disaster. It is not a practical thing. It looked very smart to start with, but we won't spend any more money on that kind of things.

MR. GAWLAK: Sir, have you tried any of your systems in a mill situation; any of your—Any of the prototypes? Or did you just discontinue at the prototype stage?

MR. HOCUTT: Are you talking about weaving?

[2392] MR. GAWLAK: Anything past roving.

MR. HOCUTT: Oh, we don't consider anything as having been tried until it is operated in the mill. I can make perpetual motion work in the lab.

MR. GAWLAK: No, sir. Well, let—No, really; I guess I don't understand what you are saying. You have tried prototypes in your lab, but you have never tried any of these prototypes in the mill?

MR. HOCUTT: No, no. The machine that was developed for cleaning a loom, you know; this—Whether it was effective or not was proven in the cotton mills; not in the lab. What I am saying is we always test these things in a mill.

MR. GAWLAK: Okay. So when you are saying you have discarded some of these hypotheticals in your paper, you have tried—

MR. HOCUTT: They were all tested. They were all tested in operating mills.

MR. GAWLAK: Fine. Thank you.

MR. HOCUTT: I described the development of the application of electrostatic precipitators to these filter systems, in my written testimony. Now, we did that for three years, but all of the experimenting and all of the testing was done in an operating cotton mill.

MR. GAWLAK: Fine. Do you see any input from other [2393] dust control technologies, non-textile?

MR. HOCUTT: We make filters for the furniture industry; we are, I am sure, the leading supplier of filters for wood dust in the United States. We are making filters now for the grain industry. We make specialty air-washers for all types of industrial applications and specialty air-conditioning products; so yes, we have quite a broad application, I think, of other technology, and world-wide communication with people who are prominent in the business.

We have access to all of the technology of the largest manufacturer of air conditioning for textile mills in the world, and also the largest manufacturer of air-conditioning systems for comfort cooling and noise and dust control in Europe. We have access to all that technology, for instance.

MR. GAWLAK: Mr. Hocutt, would you say, then, that the state of the art in dust control technology past roving, from roving through weaving, is frozen, then?

MR. HOCUTT: I would say that the state of the art is what I have described.

MR. GAWLAK: Okay. And it is not advancing. It won't be advancing in the next seven years?

MR. HOCUTT: Well, I cannot envision any breakthrough that will solve the problem in existing mills. I certainly do not.

[2394] MR. GAWLAK: Okay. Let me move on. In talking about your study, there are a few assumptions I have made, and I want to make sure they are correct. We are talking about cotton mills; pure, 100-percent cotton mills?

MR. HOCUTT: No. Cotton mills or cotton and synthetic blend mills.

MR. GAWLAK: What kind of blend would we be talking about? Percentage?

MR. HOCUTT: Whatever the blend; any, the complete range.

MR. GAWLAK: Okay. So when you give a—

MR. HOCUTT: Aw we understand the OSHA standards, they apply in processes with blends, no matter what the proportions.

MR. GAWLAK: Would it not be true that the amount of lint you would get from a 15 percent, 15 percent cotton, 85 percent synthetic, would be less than you would get with the reverse proportions?

MR. HOCUTT: Well, not necessarily, because in many mills, the cotton would be run through many of the processes before it is blended with the synthetics. And so in that case, you would be dealing with 100 percent cotton until the blending operation. Quite often that doesn't take place until the draw-frame.

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[2396] MR. GAWLAK: I understand. Mr. Hocutt, in your statement, when you are discussing warranties, you mention that you would offer a warranty of 1 milligram total dust, or .5 milligrams of vertical-elutriated dust. Are you implying some conversion there?

MR. HOCUTT: Well, we find that in the areas of opening, picking, and carding, that the vertical elutriator reading is likely to be about half of the OSHA aerial sampler reading, if that answers your question.

MR. GAWLAK: And those are the only areas where you would—

MR. HOCUTT: You were asking about the correlation between the samplers, I believe.

MR. GAWLAK: Right. That is more or less what I was getting at.

MR. HOCUTT: Right.

MR. GAWLAK: Is that only valid in those three operations?

MR. HOCUTT: Oh, yes. It is only valid in those areas, because the ratio of lint to dust changes, after you pass carding.

MR. GAWLAK: Could you give us your opinion as to what the correlations are in further processes?

MR. HOCUTT: No, we never have—I don't have enough data to be useful, I think, beyond that area; but you [2397] see, all of the work we have been doing is in opening, picking and carding, and we have piles of data on those areas.

MR. GAWLAK: Do you have any feelings for the trend? Are we getting a smaller fraction of vertical elutriated dust as we move on down the processing line?

MR. HOCUTT: Well, I don't think there is any question about that, what data we do have indicates—And of course, there is a more practical reason for that being true. Every machine cleans some dust out of the cotton.

The draw-frame takes out surprising amounts of dust. And all you have to do is walk through a mill and look at the waste that is formed at each machine.

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[2419] MR. HOCUTT: Well, I'm beginning to wish I hadn't said anything about this, which I did, and I have to be helpful. Practically all of this information that I have is confidential and I couldn't reveal any of the sources. You can only take my word for the figures. I can't substantiate it in any manner. Shall I proceed?

MR. GAWLAK: Proceed.

MR. HOCUTT: 28 percent of these looms then, would be greater than .75 milligrams per cubic meter. 52½ percent [2420] would be greater than .5. 69 percent would be greater .35. 83 percent would be greater than .2.

MR. GAWLAK: Sir, as of what date are these figures?

MR. HOCUTT: These figures include all of the dust level data that we received from the ATI people, along with a questionnaire which I described in my written testimony, plus all of the dust level reading in weave rooms that we have in our files at Pneumafil Corporation.

MR. GAWLAK: Okay, sir. Now, these two—the ATI report and the Pneumafil report are combined for the data you just gave us? The reports from your files from the ATMI survey you refer to in your—are combined?

MR. HOCUTT: We added to the data that was given us by ATMI, along with the questionnaire.

MR. GAWLAK: Sir, you mentioned that confidentiality. Are you referring to the material in Pneumafil files?

MR. HOCUTT: Am I referring to what?

MR. GAWLAK: The material in Pneumafil's files. You mentioned the ATMI and the Pneumafil files.

MR. HOCUTT: Well, I—

(Witness confers with Counsel.)

We cannot identify the source of any of these measures.

MR. GAWLAK: Sir, are both sets of material [2421] confidential?

MR. HOCUTT: We don't have any data of this kind in our files from any cotton mill in the United States that is not confidential.

MS. SIMMONS: Your Honor, at this time the agency would like to request of Mr. Tobin as the representative of ATMI, that ATMI furnish both a copy of the ATMI questionnaire referred to by Mr. Hocutt in his testimony and all responses to all questionnaires sent to all member mills which represent 369 completed questionnaires. This would include data on the processes in the mills, the state-of-the-arts with regard to machinery and engineering controls, and all environmental dust sampling. We also request at this time the additional environmental dust sampling data provided by ATMI on the 70 mills, as stated in Mr. Hocutt's testimony.

In addition to this, to the extent that this questionnaire or another questionnaire was the basis for the information on medical surveillance programs and sampling data, the results of the questionnaires in pulmonary function tests, of which were used by ATMI as reflected in the survey presented by Dr. Imbus in tables 1 through 4 of his testimony. If this request as stated on the record now is not sufficiently specific, Mr. Tobin, I would like to know now.

MR. TOBIN: Well, it went fast enough so that I couldn't keep up with it. If there is any request like that, [2422] Your Honor, 1) we would prefer to have it in writing, 2) the reason a great deal of this information is confidential, as far as—not a great deal—all of the information is confidential in regard to the dust level reading, is that the back-up data that is involved would contain information that would reveal competitive items, even if the names were deleted from the return of the

questionnaire, that would place each individual company at considerable competitive disadvantage in relation to the other, because it can be deduced from this kind of information—what kind of yarn is being run, what kind of counts, what kind of end product, and obviously in a highly competitive and fragmented industry such as the textile industry, considerable damage would be done to each individual company by revealing this kind of information. That's not a final answer to the request. But I want to point that out and make it clear on the record that that is in fact the case.

MS. SIMMONS: Mr. Tobin, I would like to if I might, obtain a final answer at this time. The agency requests that this material be furnished to it a week from tomorrow, which I believe is May 7? May 6.

MR. TOBIN: Well, I am not going to give a final answer at this point, Your Honor. I also think there's a severe question of appropriateness in if this information was furnished—it would be furnished in any event in some form before the record closes.

[2423] MS. SIMMONS: Mr. Tobin, the request being made by the agency is that the information that I just specifically described be made available one week from tomorrow, May 6, while the record is still open and while the hearing is still on-going. I would like a definite response on the record to this request at this time.

MR. TOBIN: Well, if you're going to force me to give the answer at this time, the answer is no.

MS. SIMMONS: Okay, fine.

JUDGE FATH: Ms. Simmons, this is a matter of request I think with serious import. Before Mr. Tobin and ATMI, and when I understand that you would like an answer right away, I think that we ought to delay our response for an hour or two to give Mr. Tobin an opportunity to consult with his clients. I think this is only fair. Additionally, Mr. Tobin has requested that you put your request for specific items of information in writing; you might consider that.

MS. SIMMONS: Yes, Your Honor, I will—would be very willing to put this request in writing and to present it to Mr. Tobin some time during today, if I could possibly have a response from him by the close of this hearing today. The other thing that I would like to state for the record at this time, is that it is the agency's intention in the event that this request is denied to pursue compulsory process in obtaining this data.

[2424] MR. TOBIN: Apparently, Your Honor, we can't pursue compulsory process to Dr. Bouhuys' study and published report, so the question of fairness does enter into the proceedings.

JUDGE FATH: Mr. Tobin, I don't think there is much I can do about all of this. I have taken the position and I think I'm correct in that I can't require the production of any documents or rule on the propriety of your response to the request for information. I suggest that we pass the matter now, and I ask that you give some definition of your position before 5:00 in the recess this afternoon. Is that satisfactory?

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[2437] DR. LESOURD: I understand. Partly, this is to help me understand. Another question. If you—at the drawing and roving level in the dirty or dusty mill, or the category 1 that is the larger problem, you use a considerably higher air-flow rate on that area of drawing through roving. If this were used in another—let me back that. Is it possible to use this sort of high-efficiency cleaning, that is, high air flow, where the cotton is not so dirty, and thus reduce the dust in later processes. Does it have to be in this combination? You see what I'm driving at?

MR. HOCUTT: I'm not sure I do, but I say again, [2438] I am trying to compare extremes. In category 1, I have tried to describe a mill that would require the most of everything in terms of lint and dust control, and in category 4 a mill that would require the least.

DR. LESOURD: Well, let me amplify it just a little. Yesterday I think I remember your saying that the roving is a very dusty process—that this is one that generates a lot of dust—the process tends to be one—

MR. HOCUTT: Well, I think I said that about drawing because roving, you can expect to be about half as much as drawing.

DR. LESOURD: Drawing and roving. More broad.

MR. HOCUTT: Yes.

DR. LESOURD: At any rate, in this part of the process, we are concerned about the possibility of meeting the .2 level, or even .5 at weaving, and of meeting the .2 in the spinning, winding, spooling area. My question is "If we applied a more efficient cleaning at the drawing-roving stage, not the minimum necessary to meet the .5 —but the maximum cleaning that could be accomplished there, would this reduce the dust, then that would occur at the subsequent stages, and would this make it more possible to reach the lower standards at the stages after combing, or spinning it on? See what I'm driving at? You've indicated—

MR. HOCUTT: I think I do. You're saying if we [2439] collect and filter out dust in one process, does it make the machines in the subsequent processes generate less dust? I think it probably does, but I have no idea of the degree.

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[2450] And I talked to Arthur at some length. We tried to estimate these things, and we arrived at some figures which I gave for weaving. Now, spinning frames —spinning is not usually on the ground floor, except of course in one-story mills. Most new mills are one-story mills, and quite often that is on a concrete floor, and you, of course, can realize there is a ridiculous problem of installing duct-work under a concrete floor.

But the problem in spinning rooms in older mills which are multi-story is that we have some room in the

operation underneath the spinning room floor but we don't have unlimited room. We cannot get ducts in these rooms that handle five or six thousand cfm per spinning frame. The broken ends collection system handle from, say, 1,000 to 1,600 cfm, and maybe some are more than that, and some go up to like six cfm per spindle.

And at that point we have about reached the air quantity that is necessary to condition the room for temperature and humidity control. At anything beyond that, as Mr. Thomas I am sure will tell you, it begins to throw things out of [2451] balance.

Now, as long as the duct size is controlled by 1,000 to 2,000 cfm per frame, we think we could get some of these in, see? But there is just not going to be space for these larger air quantities that would be necessary to lower dust levels that we have used for the basis of our figures.

And in weave rooms, of course, we usually find these on the ground floor. And we have estimated—by "we" I mean the knowledgeable people that I have conferred with to try and find some numbers to answer your question—maybe 10 percent of the mills in the country would have some area underneath the weave room floors which would be adequate for ductwork to handle air quantities that we have specified in our report.

DR. LESOURD: Thank you. I think you have indicated that new equipment, like new cards, or automatic opening systems have built in some dust control equipment, and that in addition, they need engineering controls added to meet the .5 to .2 standards that are proposed.

MR. HOCUTT: That is true, but I want everyone to understand that the only thing you can build into the machine is the dust-capture system.

DR. LESOURD: Right.

MR. HOCUTT: None of these machines have filter systems built into the machine. That would be absurd.

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[2464] MR. HOCUTT: Bob, we can achieve with the old machinery now existing in the mill any dust level that can be achieved with any new machinery. There is no magic in the new machinery. When you buy new machinery, you are buying built in dust controls. On the old machines, we put the same kind [2465] of things on the old machines. There is a difference in air quantities that do affect costs because it is more efficient to design these things all at one time than separately but they can't do anything except what we are doing. The end result is the same thing.

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[2494] MR. PERKEL: Is it fair to say then that you made a judgment with respect to every type of equipment that all of the manufacturers of and installers of this type of equipment made since 1961? And made a judgement as to which ones of them were still usuable toward the goal in mine and which were not. Is that correct?

MR. HOCUTT: Yes. And this is made easy, Mr. Perkel, because we were about the only ones until in the early '70s that did any of this kind of thing except on cards.

MR. PERKEL: But in cards, you did have to go through the other vendors information of this sort. Is that right?

MR. HOCUTT: Yes.

MR. PERKEL: Would you make available to us the information that you used as a basis for deriving these figures?

MR. HOCUTT: I couldn't do that. It is not my information.

MR. PERKEL: I am telling you about the information of the Pneumafil Company.

MR. HOCUTT: That information was gathered by HMI. [2495] I don't own it.

MR. PERKEL: Your Honor, I would like to make an observation if I could about the last response from this witness. It seems to me that by referring to some other data or some other source, he is in effect foreclosing our right to question him concerning the basis for his estimates. If we don't have the data, we can only have his conclusions and therefore, we are foreclosed from exercising our right to question him.

JUDGE FATH: Well, Mr. Perkel, as I have stated again and again, I don't have the authority to force the disclosure of these sources. The record will contain your objection.

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[2503] MR. PERKEL: On the bottom of page 4, you described certain tabulations that you made or were made of each type of processing machinery. Some of it we based upon the HMI survey that has been referred to here. Is that correct?

MR. HOCUTT: You are talking about the last paragraph, Mr. Perkel?

MR. PERKEL: Yes. Is this the information obtained from the ATMI, sir?

MR. HOCUTT: Let me read it, please, so I will know what you are talking about. Oh, yes. Now, what is your question?

MR. PERKEL: Was the information that you refer to on the bottom of page 4 obtained from the HMI survey?

[2504] MR. HOCUTT: Yes. This was taken off of the questionnaires.

MR. PERKEL: And you performed certain operations in order to calculate the area of quantities required in the course of the equipment. Can you tell us what you did to those data in order to arrive at your estimates? How do you go about doing that?

MR. HOCUTT: We tabulated a number of machines and then we used our standards for air quantities for dust controls and applied this to—multiplied that by the number of machines and we arrived at a total air quantity and we had also calculated an average, industry average price for that type of application so we multiplied that by CFM and that gave us a total dollars for that type of machinery.

MR. PERKEL: Well, getting back to that one set that you just described. Are you saying that when you had the data from the questionnaire that tells the equipment in a mill, you have some standard tables that give you the quantity of CFM that is required to reach various levels, that applied to different types of equipment of different ages?

MR. HOCUTT: Oh, you certainly have seen some of these in our NIOSH reports. Some of those data are still good. Some have been modified.

MR. PERKEL: Well, I am not asking you whether I have seen anything. I am asking you a specific question and [2505] I would appreciate it if you would answer it.

MR. HOCUTT: I will try, Mr. Perkel.

MR. PERKEL: Okay. Do you have certain standard tables that you use that you applied in this case to all of the equipment that is reported in the HMI survey?

MR. HOCUTT: We have guidelines on opening, picking and carding. And the air quantities for draw frames and roving frames and combers are based on established functions of the machine which are pretty apparent. Now, beyond roving, this was a matter of getting the best informed people in our company together and I said somewhere in here that beyond roving, it is all educated guessing.

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[2559] MR. GAWLAK: In places you have used the term "the investment will be non productive." Now, the RTI estimate was based on more or less of a static tech-

nology situation. We talked about retro fitting of machinery, they did not really discuss modernization such as the installation of high speed cards. Now to the extent that there is modernization that wouldn't be reflected in your statement, is that true.

MR. FIGH: Maybe this doesn't answer your question, but I think maybe it will clarify the issue that you are addressing it to, I think if you take a say a small to medium sized mill and they come into us to borrow money and they want to buy open end spinning equipment as adverse to strictly non productive. I think we would tend to look at it a lot more favorably because we would see a cash flow on a pay back on that equipment, whereas they come in and have to buy equipment that is going to cost them more to operate, I think it would be a much more difficult thing to finance.

I know that doesn't answer your question exactly, but I think it hits the issue.

MR. GAWLAK: No, fine, that did bring to light something I was interested in, thank you.

Sir, could some small companies processing pure cotton find some relief in a switch to a cotton blend?

MR. FIGH: I would expect most of them have and as [2560] a matter of fact I know a number of both small and large companies that are going over to the polyester blend and I think there are a number of reasons for that. I think part of it is properties of the fabric and the consumers are adjusted to it.

There has been a trend that way, but again there are certain products that I think are going to tend to have to always be cotton. I think towels are one that would be predominantly cotton where you need the absorbence and the polyester does not have the properties, so you have to live with that.

MR. GAWLAK: Right, but there will be some relief for small companies, you would agree with that?

MR. FIGH: Well, I think you have probably seen the greater relief already. I think that the polyester has

grown at the expense of cotton over the last 10 years and I think it has penetrated most of the markets that it can penetrate. There are some markets where you have to take into consideration the consumer preference like many men prefer a 100 percent cotton shirt.

And if you take that off the market they can certainly live and have a polyester blend shirt but if the consumer wants it, then where are they going to get it?

MR. GAWLAK: Then you are saying that there has been so much conversion that you don't envision any further [2561] conversion to greater synthetic blends or to synthetic blends?

MR. FIGH: I wouldn't use the word any, but I think the majority of it, the growth of polyester at the expense of cotton, has been completed. There are areas that are effected there, there are economic factors and there are market factors. But I think the greater part of that growth has happened already happened.

MR. GAWLAK: Okay then, so to the extent the dust levels are reduced, that has occurred already.

MR. FIGH: From the polyester, to a great degree, yes.

MR. GAWLAK: Could you tell me when this change has been occurring, how long it has been occurring, when the bulk of it has been completed?

MR. FIGH: Well, I guess it goes back maybe to a little bit before my time in the textile industry, but as early as the mid-1950's, there began to be these wash and wear shirts that were blends of polyester and cotton.

They were a very small percentage of the market and over the years that percentage has grown and the blends of the man-made fibers with cotton have continued on a relatively steady basis. Mid '50s I would guess, somebody can correct me on that.

MR. GAWLAK: Would you say the bulk had converted [2562] sometime in the '60s, could you in any estimate that?

MR. FIGH: It was probably in the '60s and through 1974.

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[2592] MR. CHAPMAN: I could not give—the dust control system is built into the spinning frame, and by buying open-end spinning, we were able to combine three machine processes into one, and rather than having to put dust removal equipment on the roping frame, which prepares to slide up for the spinning frame, and then on a winding frame, which we would have to take up after the spinning—after convention spinning—we were able to combine roping, spinning and winding into one machine, have all the dust removal equipment on that one machine. So as to how much, all I know is that when we bought 26 of them from flat, we had to install some American dust removal equipment to make it work the way we wanted it to.

MR. PERKEL: And did that affect your cost in the same way as your reference before—

MR. CHAPMAN: No. No. It reduced our cost.

MR. PERKEL: Beg your pardon?

MR. CHAPMAN: It reduced our cost.

[2593] MR. PERKEL: It reduced your cost.

MR. CHAPMAN: The open-end spinning did.

MR. PERKEL: I see. So, by installing open-end spinning, you not only reduced your dust level and combined three operations into one, but you reduced your unit costs. Is that correct?

MR. CHAPMAN: Not when we added all together. When we took the opening through the open-end spinning—

MR. PERKEL: I wasn't talking about opening, sir. I was talking about the specific open-end spinning which is discussed—

MR. CHAPMAN: I was using the unit label cost. We did not reduce our overall cost because of the cost of capital.

MR. PERKEL: And you are talking about open-end spinning—the substitution of open-end spinning for the ring-spinning and winding and robing? It reduced your labor cost and not your overall cost. Is that your statement?

MR. CHAPMAN: Right. Cost of capital.

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[2950] MR. GAWLAK: Fine. Thank you. Is it possible to compare the cost of controls of new equipment with the cost of controls to retrofit old equipment? Can that costing be made as a comparison?

DR. REIST: Let me thing. When you say new equipment, you mean a second generation high speed cards versus dimensional cards?

MR. GAWLAK: Yes.

DR. REIST: I am sure that these comparisons can be made for specific units but it would seem to me that to try to get too much detail, you couldn't generalize too much, except to say that everything that we have seen seems to indicate that [2951] it isn't excessive. In other words, it seems to me that you gain by going to new units of new control.

MR. GAWLAK: Okay. Let me ask you another question. It will be somewhat general and perhaps also a bit more specific at the same time. If air flows are similar, would the capital cost of controls for old and new processes be similar?

DR. REIST: If their air flows were the same?

MR. GAWLAK: Yes. Would the capital costs be the same for retrofitting old equipment and installing new equipment?

DR. REIST: I expect they would be less for the new equipment because you are talking about air flows in terms of so many cubic feet per minute per machine, but the machine's productive capacity has been increased by maybe a factor of two to four. So, for the same productive capacity, you have actually reduced the number of

machines. Therefore, you would reduce the total air requirements.

MR. GAWLAK: Dr. Reist, you indicated that high speed cards cannot be used for all grades of cotton. Do you know of any other limitations to the introduction of high speed cards or opening equipment?

DR. REIST: We didn't come across any other ones that I can think of. No, nothing jumps to mind.

MR. GAWLAK: Do you know if the extra cleaning we would see would affect process quality, affect product quality?

DR. REIST: From what we have found, you really have [2952] to consider two factors. First you have to consider the effect of additional flow within a machine on product quality. I think I mentioned yesterday that it seems that maybe 1500 cubic feet per minute per card might be an upper limit. I have just seen that once or twice. So beyond that, there would be and effect on product quality.

On the other hand, the fact that there is ventilation, there is air cleaning there, since the carding process does liberate dust, lint, and so on from the raw cotton, that having some ventilation certainly would, I would think, improve the cotton quality because it would keep it from collecting in the machine itself.

MR. GAWLAK: Fine. Do you know from your survey if the introduction of new equipment or processes has required building modifications or construction?

DR. REIST: I would think that there would be. I know that some of the new high speed cards are substantially heavier than the conventional cards. I don't know much about the load-bearing capacity of cotton mill floors, but I would imagine that that would certainly have to be taken into consideration and that might be a factor. But in our processing that I cited yesterday, all of these items were included. Those were the total costs for that particular mill when the three alternatives were

considered. Even considering whatever changes were necessary, the comparisons were still favorable.

[2953] MR. GAWLAK: I see. Would there be any construction or modification costs involved in any other process than carding that you know of?

DR. REIST: Beyond carding you mean?

MR. GAWLAK: Yes.

DR. REIST: I don't know. We didn't look at that.

MR. GAWLAK: Do you know if there will be any construction costs related to the dust control equipment as opposed to the card itself that might require extra construction?

DR. REIST: One thing that definitely is required is a fairly good filtration system. In order to get this, generally you would expect to pay slightly with a greater pressure across the filters. You need more suction in the system essentially. This means a slightly larger fan size. I don't know whether that would require substantial modifications or not. There would have to be some modifications. I might point out though a fact which has been recognized, of course, and I think is one of the big selling points in going from the slower speed cards to higher speed cards is that, again for the same productive capacity, a lot of floor space is freed. In other words, if you go from 100 cards to 30 cards, you free up the space that those other 70 cards occupied.

MR. GAWLAK: I see. So in a sense then, you would have more room to put in dust control equipment which might otherwise have to placed on the roof or outside, is that correct?

[2954] DR. REIST: You could look at it that way. I think one of the things also is you certainly have less runs of ducts. The duct lengths can be less. You have concentrated the forces in a small area. Just from that standpoint alone, I am not sure I could say it becomes easier to do, but at least you got it all in one spot.

MR. GAWLAK: Okay. Another question that I am interested in is how would construction or modification costs for new equipment compare with modification or construction costs to install controls on existing equipment?

DR. REIST: From what I have been told, one of the problems with existing equipment is that great illustration that was in the NIOSH book, and I guess you every now and then, I'll bet it is in the record somewhere, of the cotton card showing the 12 points of dust emission. One of the problems with installing controls on existing equipment is to pick up the dust emitted from those 12 points. Now I understand with some of the newer card designs, the number of emission points have been reduced, so it could be a little easier to control as there are less places the dust can come from the machine. But that is what I have heard, I couldn't give you a specific reference.

MR. GAWLAK: Let me ask you to direct yourself also to point of physical construction in the mill, if we compare the old to the new processes from a physical construction [2955] viewpoint. Could you compare those costs at all?

DR. REIST: If I understand your question, I am not sure I can.

MR. PERKEL: Ask him to clarify it.

DR. REIST: Let me repeat it and you tell me if I have got your question right. You want me to compare construction costs for new equipment versus modifications to existing equipment, is that right?

MR. GAWLAK: Yes. In a general way.

DR. REIST: This is just a guess, a guess based on the material we looked at. But I would guess that the construction costs would be a little higher for the new equipment than modifications for the existing equipment. I may be wrong, but that would be a guess.

MR. GAWLAK: Could you be a little more specific as to why those costs would be higher?

DR. REIST: I mentioned earlier, you have heavier units, for example. The duct work and the modifications are sort of add-ons on the machines, on existing machines. Whereas with the new machines, you are changing your whole configuration of the machine layout. You may actually change the type of raw cotton feeding mechanism to the card which might make changes.

MR. GAWLAK: Dr. Reist, were you here for Mr. Hobin Holzits(?) testimony?

DR. REIST: No.

[2956] MR. GAWLAK: One of his points was that card rooms were very crowded and pre-separators and rotary tongue filters were extremely large and most of the room would be used up and they would have to be placed on the roof or in a separate facility. Taking this into account, would that change your estimate of the cost of construction for new equipment versus retrofitting old equipment?

DR. REIST: Yes, it would as a matter of fact. I hadn't thought of that before, but because you are making more space available, it ought to make that less expensive for new equipment.

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[2999] [Prof. Burgess:] The question we are frequently asked is, "How long can one use a respirator?" I am marvelled by the standard when [3000] I look at the time period, I consider this question based upon seven year implementation plans. The acceptable wearing times, many of us have made statements. Breslin, who is with the AEC, has had a good deal of experience in the real world in respirator programs. I cite this in my statement. He feels that one hour is probably tops, and you should really hold respirator use to less than 20 minutes.

Bruce Hald, a chap at Lawrence Aviation Laboratory, who I believe has spoken before this body earlier, has suggested that one can't use a respirator for more than one or two hours. At that point one needs a break. I have worn a respirator a good deal in this study and I suggest that all of us who are involved in the issuance and the application of respirators do so. I feel that I personally can wear a respirator for about an hour, then my nose starts to, as well as other parts of my anatomy, really wants a break.

So we are talking here about statements from people in the field who have worked with respirators can effectively state that these devices are not suitable for continuous use. They are valuable when used on a intermittent basis, but I do not feel that it is suitable for continuous use.

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[3010] MR. GAWLAK: Dr. Burgess, do you know of any industry where workers wear respirators a substantial amount of time?

PROF. BURGESS: Yes, may I give you a range?

MR. GAWLAK: Fine.

PROF. BURGESS: It is my understanding that in smelters in the West, the workers will wear respirators about 10% of their shift. In coal mines, we found that they could wear a respirator, possibly, 20% of their shift. On coke ovens, possible 25% of the shift. Therefore, I think this supports my earlier statement that they aren't suitable for continuous wearing. In all of these three applications, there are pulses of exposure. During those pulses of exposure, when engineering control has not been implemented, the respirators have been worn.

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[3015] MR. DAVIS: My name is Frank Davis. I am from Local 1604 from Canton, Georgia for Canton Textile Mills. As you can evidently see, with the use of this respirator, you cannot hear yourself or anyone else over

machinery. It is like wearing a heater over you face. When you breathe, you rebreathe your hot air again before it can get out. And after [3016] just a few minutes, this filter here, which you can see is some kind of cotton, it is stopped up. It just cuts your breath off and it chokes you more than anything else. This is just like wearing a heater over your face.

After a few minutes of this, you are sweating so bad, you can't hardly wear it. You drown yourself. You know, you breathe in water and everything. You can't wear it with glasses. If you are like me, you have to wear your glasses or you can't see. These things, they don't seal. This kind, it seals pretty good but if you talk, your lower lip will come below this rubber ring here.

Now we had some paper types, you know, the single use respirators. We had some of those and somebody relieved me of my box when we checked out of the hotel. Anyhow, some of the single use are real good. You start sweating and then they will just kind of turn into a lump of lint then.

Others are made like an envelope. They are folded up with a long—and when you unfold them and put them on, they leave two big gaps at each jaw and one under your chin. That is just like not even wearing a respirator. I think you cannot be protected fully by a respirator. You can't wear them any length of time at all.

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[3017] [Mr. Mabe:] It is required that I wear a face mask when working in the carding and drawing section, which is the type he mentioned and was aiming to show earlier. They are real uncomfortable. [3018] After you wear them in 80° temperature with 50% humidity for approximately two to three hours, under working conditions, they are wet from perspiration and practically as much dust as the type of card that we use at the present emits in the air. It takes about three hours for them to

almost block plum off until they look like you just picked them up out of a dust pile or out of the road where the traffic has been a running.

They are ill fitting. They have a metal piece across here which, if you wear glasses, they come up right across here. When you put them on, they fog your glasses up. In my job, working around machinery, it really makes it kind of hazardous because when my glasses fog up, as anyone who wears them will know, it is kind of hard to see what you are doing, expecially if your lighting situation isn't exactly favorable.

* * * * *

[3040] [Mr. Frumin:] Another major problem which Mr. Held has testified to, and Mr. Shutes and Mr. Burgess, is the problem of poor fit. And in that connection I would like to refer to Section 1910.34 of the existing Health and Safety Standards. I don't [3041] have that before me, so I can't quote the paragraph number, but in several cases, at several points in that standard, it refers to "the men"; for instance, in the area of training and supervision, I believe it says words to the effect that the men ought to be given an opportunity to try on various respirators.

I am not ascribing any prejudice to the authors of this standard. I am simply saying that it was written without any concern for women. And inasmuch as women will constitute a significant percentage of the workers who are going to have to wear respirators in the cotton textile industry, that oversight on the part of the authors of that standard is instructive.

Most respirators are not designed for women's faces. And anyone who believes that requiring the use of existing respirators by women, who believes that that requirement will protect workers, simply is uninformed.

Furthermore, even if proper fit is achieved and a worker manages to overcome the discomfort, the idea of a respirator on a worker who is already ill, who has

already suffered an impaired lung function, is a very cruel form of punishment to me, it seems to me.

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[3043] Finally, the symptoms of byssinosis are not those—The initial symptoms are not those which lead workers to believe that it is a very serious problem. Of course, that is not the major reason workers don't understand that. They don't understand it because aside from what the union has told them, very few people have told them anything about it.

But the—When you go to work on Monday and the symptoms disappear by Monday afternoon or Tuesday morning, you figure, "Well, I will get used to it." I have heard that [3044] so many times; I couldn't count the number of times I have been told that by workers: "Why wear a respirator?" It requires proper administration of a program to see to it that workers are properly informed.

* * * * *

[1031] DR. MERCHANT: I think I addressed that point in terms of the objective of the study. We were looking not only at prevalence in various mill processes, but we were looking for the determinants of respiratory disease and we were interested in looking at a number of high dust areas.

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In developing dose response curves, however, we did get a good distribution of the dust over a large variety of dust measurements and we did find striking dose response relation- [1032] ships.

EXHIBIT 62, ATTACHMENT II

ATMI ECONOMIC IMPACT STUDY
Estimated Temperature and Relative Humidity Compliance Cost (Dollars)

Dust Level MG/M3	Textile Process	Equipment Cost	Annual Maintenance Cost	Annual Energy Cost	Operating Brake Horse-Power
.2 VE	Opening	11,645,665	221,824	689,103	9,212
.2	Picking	19,803,067	500,603	1,516,019	19,748
.2	Carding	51,818,179	1,343,577	4,545,772	59,914
.2	Sub-total	83,266,911	2,066,004	6,750,894	88,874
.2	Drawing	32,480,565	770,551	2,322,307	30,077
.2	Combing	5,560,851	126,895	381,899	4,934
.2	Roving	25,595,645	624,524	2,042,940	24,456
.2	Opening-Roving Sub-total	146,903,972	3,587,974	11,498,040	148,341
.5	Spinning	4,286,350	143,698	209,323	4,278
.5	Twisting				
.5	Winding	5,283,507	164,371	210,252	4,297
.5	Spooling	1,210,988	33,890	43,303	885
.5	Warping	—	—	—	—
.5	Spinning-Warping Sub-total	10,780,845	341,959	462,878	9,460
1.0	Slashing				
1.0	Weaving	24,098,472	723,621	1,984,909	28,306
	TOTAL:	181,783,289	4,653,554	13,945,827	186,107

NOTE:

Same notes on ATTACHMENT I apply to ATTACHMENT II

[Notes reprinted in Pet. App. at 156.]

IV. ORDER OF SUPREME COURT GRANTING PETITIONS FOR WRITS OF CERTIORARI IN NOS. 79-1429 AND 79-1583

[Order of the Supreme Court of the United States filed October 6, 1980]

79-1429

AM. TEXTILE MFGRS. INST.

v.

MARSHALL, SEC. LABOR, ET AL.

79-1583

NATL. COTTON COUNCIL, ETC.

v.

MARSHALL, SEC. LABOR, ET AL.

The petition for a writ of certiorari in No. 79-1429 is granted limited to Questions 1, 2 and 4 presented by the petition. The petition for a writ of certiorari in No. 79-1583 is granted. The cases are consolidated and a total of one hour is allotted for oral argument.

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